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LECTURES AND ESSAYS

By **PROFESSOR TYNDALL**



WATTS & Co.,
17, JOHNSON'S COURT, FLEET STREET, LONDON, E.C.

(ISSUED FOR THE RATIONALIST PRESS ASSOCIATION, LIMITED)

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LECTURES AND ESSAYS

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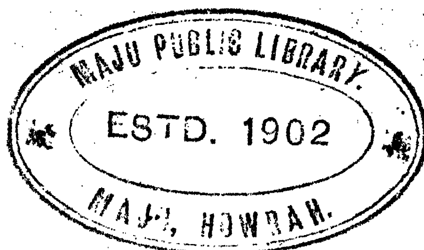
LECTURES AND ESSAYS

JOHN TYNDALL

(Cullings from "Fragments of Science")

[ISSUED FOR THE RATIONALIST PRESS ASSOCIATION, LTD.]

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1906



BIOGRAPHICAL SKETCH[1]

JOHN TYNDALL, natural philosopher, son of John Tyndall and his wife Sarah (Macassey), was born at Leighlin Bridge, co. Carlow, Ireland, on August 2nd, 1820. The Tyndalls, who claimed relationship with the family of William Tyndale the martyr, had crossed from Gloucestershire to Ireland in the seventeenth century. The elder John Tyndall, son of a small landowner, although poor, was a man of superior intellect, and he gave his son the best education which his circumstances could afford. At the local national school young Tyndall acquired a thorough knowledge of elementary mathematics, which qualified him to enter as civil assistant (in 1839) the ordnance survey of Ireland. In 1842 he was selected, as one of the best draughtsmen in his department, for employment on the English survey. While quartered at Preston in Lancashire he joined the mechanics' institute, and attended its lectures. He was at this time much impressed by Carlyle's *Past and Present*, and to the stimulating influence of Carlyle's works was in part due his later resolve to follow a scientific career. On quitting the survey Tyndall was employed for three years as a railway engineer.

In 1847 he accepted an offer from George Edmondson, principal of Queenwood College, Hampshire, to join the college staff as teacher of mathematics and surveying. Mr. (afterwards Sir Edward) Frankland was lecturer on chemistry, and the two young men agreed respectively to instruct each other in chemistry and mathematics. But Queenwood did not yield all the opportunities they wished for, and they presently resolved to take advantage of the excellent instruction to be enjoyed at the university of Marburg in Hesse-Cassel. The decision was for Tyndall a momentous one. He had nothing but his own work and slender savings to depend on, and his friends thought him mad for abandoning the brilliant possibilities then open to a railway engineer.

In October, 1848, Tyndall and Frankland settled at Marburg. Tyndall attended Bunsen's lectures on experimental and practical chemistry, and studied mathematics and physics in the classes and laboratories of Stegmann, Gerling, and Knoblauch. By intense application he accomplished in less than two years the work usually extended over three, and thus became doctor of philosophy early in 1850. Thenceforward he was free to devote himself entirely to original research.

His first scientific paper was a mathematical essay on screw surfaces—"Die Schraubenfläche mit geneigter Erzeugungslinie und die Bedingungen des Gleichgewichts für solche Schrauben"—which formed his inaugural dissertation

[1] This memoir is reprinted with the consent of Messrs. Smith, Elder, & Co., given on behalf of the proprietor of *The Dictionary of National Biography*.

when he took his degree. His first physical paper, published in the *Philosophical Magazine* for February, 1851, was on "The Phenomena of a Water Jet"—a subject comparatively simple, but not without scientific interest.

In conjunction with Knoblauch, Tyndall executed and published an important investigation "On the Magneto-optic Properties of Crystals and the Relation of Magnetism and Diamagnetism to Molecular Arrangement."[1] They claimed to have discovered the existence of a relation between the density of matter and the manifestation of the magnetic force. Their fundamental idea was that the component molecules of crystals, and other substances, are not in every direction at the same distance from each other. The superior magnetic energy of a crystal in a given direction, when suspended between the poles, they attributed to the greater closeness of its molecules in that direction. In support of their assumption they showed that, by pressure, the magnetic axis of a bismuth crystal could be shifted 90° in azimuth, the line of pressure always setting itself parallel with, or at right angles to, the line joining the two magnetic poles, according as the crystal was magnetic or diamagnetic. This explanation differed essentially from that of Faraday and Plücker. In June, 1850, Tyndall went to England, and at the meeting of the British Association of that year in Edinburgh he read an account of his investigation, which excited considerable interest. He afterwards returned to Marburg for six months, and carried out a lengthy inquiry into electro-magnetic attractions at short distances.[2]

[1] *Phil. Mag.*, July, 1850. [2] *Ib.*, April, 1851.

At Easter, 1851, Tyndall finally left Marburg and went to Berlin, where he became acquainted with many eminent men of science. In the laboratory of Professor Magnus he conducted a second investigation on "Diamagnetism and Magne-crystallic Action,"[1] which formed a sequel to that previously undertaken with Knoblauch. A paper describing his results was read at the Ipswich meeting of the British Association. He showed that the antithesis of the two forces was absolute: diamagnetism resembling magnetism as to polarity and all other characteristics, differing from it only by the substitution of repulsion for attraction and *vice versa*.

The question of diamagnetic polarity was much discussed. Its existence, originally asserted by Faraday, and reaffirmed by Weber in 1848, had been subsequently denied by Faraday, who still continued doubtful. To meet all objections, Tyndall, at a later date, again took up the subject, and in three conclusive investigations, the second of which formed the subject of the Bakerian lecture delivered before the Royal Society in 1855, he put the polarity of bismuth and other diamagnetic bodies beyond question.[2] Five years were devoted by him to the investigation of diamagnetism and the influence of crystalline structure and mechanical pressure upon the manifestations of magnetic force. The original papers (with a few omissions in the last edition) are collected in his book on *Diamagnetism* (see p. 12).

Before leaving Marburg in 1851, Tyndall had agreed to return to Queenwood; this time as lecturer on mathematics and natural philosophy. Here

[1] *Phil. Mag.*, September, 1851.
[2] *Ib.*, November, 1851; *Phil. Trans.*, 1855; *ib.*, 1856, pt. i.

he remained two years. The first of the three investigations just alluded to was carried out at Queenwood, as was also a series of experiments on "The Conduction of Heat through Wood."[1] On June 3rd, 1852, Tyndall was elected fellow of the Royal Society.

While at Queenwood he applied for several positions which offered a wider scope for his abilities. On his way to Ipswich in 1851 he had made the acquaintance of T. H. Huxley, and a warm and enduring friendship resulted. They made joint applications for the chairs respectively of natural history and physics then vacant at Toronto; but, in spite of high testimonials, they were unsuccessful. They also failed in candidatures for chairs in the newly-founded university of Sydney, New South Wales. Meanwhile, soon after Tyndall's departure from Berlin, Dr. Henry Bence Jones visited that city, and, hearing much of Tyndall's labours and personality, caused him to be invited to give a Friday evening lecture at the Royal Institution. The lecture, "On the Influence of Material Aggregation upon the Manifestations of Force,"[2] was delivered on February 11th, 1853. It produced an extraordinary impression, and Tyndall, hitherto known only among physicists, became famous beyond the limits of scientific society. In May, 1853, he was unanimously chosen as professor of natural philosophy in the Royal Institution. The appointment had the special charm of making him the colleague of Faraday. Seldom have two men worked together so harmoniously as did Faraday and Tyndall during the years that followed. Their relationship from first to last resembled that of father and son. Tyndall's *Faraday as a Discoverer* bears striking testimony to their attachment. Other sketches of Faraday by Tyndall are in his *Fragments of Science* and in the life of Faraday in the *Dictionary of National Biography*.

Tyndall's career was now definitely marked out. To the end of his active life his best energies were devoted to the service of the Royal Institution. In 1867, when Faraday died, Tyndall succeeded him in his position as superintendent of the Institution. On his own retirement in the autumn of 1887 he was elected honorary professor.

In 1854, after attending the British Association meeting at Liverpool, Tyndall visited the slate quarries of Penrhyn. His familiarity with the effects of pressure upon the structure of crystals led him to give special attention to the problem of slaty cleavage. By careful observation and experiments with white wax and many other substances which develop cleavage in planes perpendicular to pressure, he satisfied himself that pressure alone was sufficient to produce the cleavage of slate rocks. On June 6th, 1856, he lectured on the subject at the Royal Institution.[1] Huxley, who was present, suggested afterwards that the same cause might possibly explain the laminated structure of glacier ice recently described in Forbes's *Travels in the Alps*. The friends agreed to take a holiday and inspect the glaciers together. The results of the observations made during this and two subsequent visits to Switzerland are given in Tyndall's classical work, *The Glaciers of the Alps* (see p. 12). The original memoirs are in the *Philosophical Transactions* for

[1] See "Molecular Influences," *Phil. Trans.*, January, 1853.

[2] *Roy. Inst. Proc.*, i. 185.

[1] See appendix to *Glaciers of the Alps*.

1857 and 1859. Tyndall, assisted by his friend, Dr. Thomas Archer Hirst, made many measurements upon the glaciers in continuation of the work of Agassiz and J. D. Forbes. He discussed, in particular, the question as to the conditions which enable a rigid body like ice to move like a river. He showed very clearly the defects of former theories, proving by repeated observations on the structure and properties of ice the inefficacy of the generally admitted plastic theory to account for the phenomena. Through the direct application of the doctrine of regelation, he arrived at a satisfactory explanation of the nature of glacier motion. The veined structure he ascribed to mechanical pressure, and the formation of crevasses to strains and pressures occurring in the body of the glacier. In assigning to Rendu his position in the history of glacier theories, Tyndall gave offence to Professor Forbes. A controversy followed, in which the fairness of Tyndall's attitude was fully vindicated.

The expedition to Switzerland, undertaken for a scientific purpose, had a secondary outcome. Tyndall was fascinated by the mountains, and from that time forward yearly sought refreshment in the Alps when his labours in London were over. He became an accomplished mountaineer. In company with Mr. Vaughan Hawkins he made one of the earliest assaults upon the Matterhorn in 1860. He crossed over its summit from Breuil to Zermatt in 1868. The first ascent of the Weisshorn was made by him, in 1861. Tyndall's descriptions of his Alpine adventures are not only graphic and characterised by his keen interest in scientific problems, but show a poetical appreciation of mountain beauties in which he is approached by few Alpine travellers.

The very important series of researches on "Radiant Heat in its Relation to Gases and Vapours," which occupied him on and off for twelve years, and with which his name will be always especially associated, were begun in 1859. He was led from the consideration of glacier problems to study the part played by aqueous vapour and other constituents of the atmosphere in producing the remarkable conditions of temperature which prevail in mountainous regions. The inquiry was one of exceptional difficulty. Prior to 1859 no means had been found of determining by experiment, as Melloni had done for solids and liquids, the absorption, radiation, and transmission of heat by gases and vapours. By the invention of new and more delicate methods Tyndall succeeded in controlling the refractory gases. He found unsuspected differences to exist in their respective powers of absorption. While elementary gases offered practically no obstacle to the passage of heat rays, some of the compound gases absorbed more than eighty per cent. of the incident radiation. Allotropic forms came under the same rule; ozone, for example, being a much better absorbent than oxygen. The temperature of the source of heat was found to be of importance: heat of a higher temperature was much more penetrative than heat of a lower temperature.

The power to absorb and the power to radiate Tyndall showed to be perfectly reciprocal. He also established that, as regards their powers of absorption and radiation, liquids and their vapours respectively follow the same order. Thus he was able to determine the position of aqueous vapour, which, on account of condensation, could not be experimented upon directly. Experiments made with

dry and humid air corroborated the inference that, as water transcends all other liquids, so aqueous vapour is powerful above all other vapours as a radiator and absorber. These results, questioned by Magnus and by a few later experimenters, but fully established by Tyndall, explained a number of phenomena previously unaccounted for. Since Wells's researches on dew, no fact has been established of greater importance to the science of meteorology than the high absorptive and radiative power of aqueous vapour. Many years later an experiment made in his presence by Mr. Graham Bell suggested to Tyndall a novel and interesting method of indirectly confirming his former results.[1]

Using a dark solution of iodine in bisulphide of carbon as a ray-filter, Tyndall was able approximately to determine the proportion of luminous to non-luminous rays in the electric and other lights. He also found that the obscure rays collected by means of a rock-salt lens would ignite combustible materials at the invisible focus; while some non-combustible bodies, exposed at the same dark focus, became luminous or calorescent. The astounding change in the deportment of matter towards heat radiated from an obscure source which accompanies the act of chemical combination, and many other points of equal importance, were first established by these researches, for which Tyndall received the Rumford medal in 1869. Nine memoirs on these subjects were published in the *Philosophical Transactions*, and many additional papers in other journals. They have been gathered together in *Contributions to Molecular Physics in the Domain of Radiant Heat* (see p. 12). This volume also includes a series of striking experiments on the decomposition of vapours by light, wherein the blue of the firmament and the polarisation of sky-light—illustrated on skies artificially produced — were shown to be due to excessively fine particles floating in our atmosphere.

While engaged upon the last-mentioned inquiry, Tyndall observed that a luminous beam, passing through the moteless air of his experimental tube, was invisible. It occurred to him that such a beam might be utilised to detect the presence of germs in the atmosphere: air incompetent to scatter light, through the absence of all floating particles, must be free from bacteria and their germs. Numerous experiments showed "optically pure" air to be incapable of developing bacterial life. In properly protected vessels infusions of fish, flesh, and vegetable, freely exposed after boiling to air rendered moteless by subsidence, and declared to be so by the invisible passage of a powerful electric beam, remained permanently pure and unaltered; whereas the identical liquids, exposed afterwards to ordinary dust-laden air, soon swarmed with bacteria. Three extensive investigations into the behaviour of putrefactive organisms were made by Tyndall, mainly with the view of removing such vagueness as still lingered in the public mind in 1875–6, regarding the once widely-received doctrine of spontaneous generation. Among the new results arrived at the following are noteworthy. Bacteria are killed below 100° C.; but their desiccated germs—those of the hay bacillus in particular—may retain their vitality after several hours' boiling. By a process which he called "discontinuous heating,"

[1] See "Action of Free Molecules on Radiant Heat, and its Conversion thereby into Sound," *Phil. Trans.*, 1882, pt. i.

whereby the germs, in the order of their development, were successively destroyed before starting into active life, he succeeded in sterilising nutritive liquids containing the most resistant germs. This method, since universally adopted by bacteriologists, has proved of great practical value. The medical faculty of Tübingen gave Tyndall the degree of M.D. in recognition of these researches. The original essays, written for the *Philosophical Transactions*, are collected in *Floating Matter of the Air* (see p. 12).

In 1866 Tyndall had succeeded Faraday as scientific adviser to the Trinity House and Board of Trade. He held the post for seventeen years, and it was in connection with the Elder Brethren that his chief investigations on sound were undertaken, with a view to the establishment of fog signals upon our coasts. Many conflicting opinions were held as to the respective values of the various sound signals in use when Tyndall began his experiments at the South Foreland (May 19th, 1873). Very discordant results appeared at first, but all were eventually traced to variations of density in the atmosphere. Tyndall discovered that non-homogeneity of the atmosphere affects sound as cloudiness affects light. By streams of air differently heated, or saturated in different degrees with aqueous vapour, "acoustic flocculence" is produced. Acoustic clouds, opaque enough to intercept sound altogether and to produce echoes of great intensity, may exist in air of perfect visual transparency. Rain, hail, snow, and fog were found not sensibly to obstruct sound. The atmosphere was also shown to exercise a selective and continually varying influence upon sounds, being favourable to the transmission sometimes of the longer, sometimes of the shorter, sonorous waves. Tyndall recommended the steam siren used in the South Foreland experiments as, upon the whole, the most powerful fog signal yet tried in England. His memoir on the subject, presented to the Royal Society on February 5th, 1874, is summarised in the book on *Sound* (see p. 12). Passing mention should be made of the beautiful experiments on sensitive flames described in the same volume.

It was likewise in his capacity of scientific adviser that Tyndall was called upon, in 1869 and on many subsequent occasions, to report upon the gas system introduced by Mr. John Wigham, of Dublin, the originator of several important steps in modern lighthouse illumination. Tyndall's inability, during a long series of years, to secure what he considered justice towards Mr. Wigham led him eventually to sever himself from colleagues to whom he was sincerely attached. He resigned his post on March 28th, 1883.[1]

As a lecturer Tyndall was famed for the charm and animation of his language, for lucidity of exposition, and singular skill in devising and conducting beautiful experimental illustrations. As a writer he did perhaps more than any other person of his time for the diffusion of scientific knowledge. By the publication of his lectures and essays he aimed especially at rendering intelligible to all, in non-technical language, the dominant scientific ideas of the century. His work has borne abundant fruit in inciting others to take up the great interests which possessed so powerful an

[1] See *Nineteenth Century*, July, 1888; *Fortnightly Review*, December, 1888, and February, 1889; *New Review*, 1892.

attraction for himself. In *Heat as a Mode of Motion* (see p. 12), which has been regarded as the best of Tyndall's books, that difficult subject was for the first time presented in a popular form. The book on *Light* gives the substance of lectures delivered in the United States in the winter of 1872–3. The proceeds of these lectures, which by judicious investment amounted in a few years to between £6,000 and £7,000, were devoted to the encouragement of science in the United States.

His views upon the great question as to the relation between science and theological opinions are best given in his presidential address to the British Association at Belfast in 1874, which occasioned much controversy at the time (reprinted, with essays on kindred subjects, in *Fragments of Science*, vol. ii.). The main purpose of that address was to maintain the claims of science to discuss all such questions fully and freely in all their bearings.

On February 29th, 1876, Tyndall married Louisa, eldest daughter of Lord Claud Hamilton, who became his companion in all things. In 1877 they built a cottage at Bel Alp, on the northern side of the Valaise, above Brieg. There they spent their summers amid his favourite haunts. In 1885 they built what Tyndall called "a retreat for his old age" upon the summit of Hind Head, on the Surrey moors, then a very retired district. Sleeplessness and weakness of digestion—ills from which he had suffered more or less all his life—increased upon him in later years, and caused him to resign his post at the Royal Institution in March, 1887. His later years were for the most part spent at Hind Head. Repeated attacks of severe illness, unhappily, prevented the execution of the many plans he had laid out for his years of retirement. In 1893 he returned greatly benefited from a three months' sojourn in the Alps. But a dose of chloral, accidentally administered, brought all to a close on December 4th, 1893.

Tyndall's single-hearted devotion to science and indifference to worldly advantages were but one manifestation of a noble and generous nature. A resolute will and lofty principles, always pointing to a high ideal, were in him associated with great tenderness and consideration for others. His chivalrous sense of justice led him not unfrequently—irrespective of nationality or even of personal acquaintance, and often at great cost of time and trouble to himself—to take up the cause of men whom he deemed to have been unfairly treated or overlooked in respect to their scientific merits. He thus vindicated the claim of the unfortunate German physician, Dr. Julius Robert Mayer, to have been the first to lay down clearly the principle of the conservation of energy and to point out its universal application; and succeeded in obtaining his recognition by the scientific world in spite of eminent opposition. The same spirit appeared in his defence of Rendu's title to a share in the explanation of glacier movement, and of Wigham's services in regard to lighthouses.

Tyndall took a warm interest in some great political questions. He sided strongly with the Liberal Unionists in opposing Mr. Gladstone's Home Rule policy.

Tyndall was of middle height, sparely built, but with a strength, toughness, and flexibility of limb which qualified him to endure great fatigue and achieve the

most difficult feats as a mountaineer. His face was rather stern and strongly marked, but the sharp features assumed an exceedingly pleasing expression when his sympathy was touched; and the effect was heightened by the quality of his voice. His eyes were grey-blue, and his hair, light-brown in youth, was abundant and of very fine texture. He had generally, like Faraday, to bespeak a hat on account of the unusual length of his head. A medallion of Tyndall, executed by Woolner in 1876, is, perhaps, the best likeness that exists of him.

Tyndall's works have been translated into most European languages. In Germany (where Helmholtz and Wiedemann undertook the translations and wrote prefaces) they are read almost as much as in England. Some thousands of his books are sold yearly in America, and a few translations have been made into the languages of India, China, and Japan.

In the Royal Society's catalogue of scientific papers 145 entries appear under Tyndall's name between 1850 and 1883, indicating approximately the number of his contributions to the *Philosophical Transactions*, the *Philosophical Magazine*, the *Proceedings* of the Royal Society and of the Royal Institution, and other scientific journals. A great variety of subjects besides those glanced at above occupied his attention. They are for the most part dealt with in the miscellaneous essays collected in *Fragments of Science* and *New Fragments*. The essence of his teaching is contained in the following publications: 1. *The Glaciers of the Alps, being a Narrative of Excursions and Ascents, an Account of the Origin and Phenomena of Glaciers, and an Exposition of the Physical Principles to which they are Related*, 1860; reprinted in 1896; translated for the first time into German in 1898. 2. *Mountaineering in 1861: A Vacation Tour*, 1862 (mostly repeated in *Hours of Exercise*). 3. *Heat Considered as a Mode of Motion*, 1863; fresh editions, each altered and enlarged, in 1865, 1868, 1870, 1875; the sixth edition, 1880, was stereotyped. 4. *On Sound*, a course of eight lectures, 1867; 3rd edit., with additions, 1875; 4th edit., revised and augmented, 1883; 5th edit., revised, 1893. 5. *Faraday as a Discoverer*, 1868; 5th edit., revised 1894. 6. *Researches on Diamagnetism and Magne-crystallic Action, including the Question of Diamagnetic Polarity*, 1870; third and smaller edition, 1888. 7. *Fragments of Science for Unscientific People: A Series of Detached Essays, Lectures, and Reviews*, 1871; augmented in the first five editions; from 6th edit., 1879, in two vols. 8. *Hours of Exercise in the Alps*, 1871; 2nd edit., 1871; 3rd edit., 1873; reprinted in 1899. 9. *Contributions to Molecular Physics in the Domain of Radiant Heat: A Series of Memoirs published in the Philosophical Transactions and Philosophical Magazine, with additions*, 1872. 10. *The Forms of Water in Clouds and Rivers, Ice, and Glaciers* (International Scientific Series), 1872; 12th edit., 1897. 11. *Six Lectures on Light, delivered in America in 1872–3*, 1873; 5th edit., 1895. 12. *Lessons in Electricity, at the Royal Institution*, 1876; 5th edit., 1892. 13. *Essays on the Floating Matter of the Air in Relation to Putrefaction and Infection*, 1881; 2nd edit., 1883. 14. *New Fragments*, 1892; last edit., 1897. 15. *Notes on Light: Nine Lectures delivered in 1869*, 1870. 16. *Notes on Electrical Phenomena and Theories: Seven Lectures delivered in 1870*, 1870.

L. C. T.

LECTURES AND ESSAYS

THE BELFAST ADDRESS[1]

§ 1.

AN impulse inherent in primeval man turned his thoughts and questionings betimes towards the sources of natural phenomena. The same impulse, inherited and intensified, is the spur of scientific action to-day. Determined by it, by a process of abstraction from experience we form physical theories which lie beyond the pale of experience, but which satisfy the desire of the mind to see every natural occurrence resting upon a cause. In forming their notions of the origin of things, our earliest historic (and doubtless, we might add, our prehistoric) ancestors pursued, as far as their intelligence permitted, the same course. They also fell back upon experience; but with this difference—that the particular experiences which furnished the warp and woof of their theories were drawn, not from the study of nature, but from what lay much closer to them—the observation of men. Their theories accordingly took an anthropomorphic form. To supersensual beings, which, "however potent and invisible, were nothing but a species of human creatures, perhaps raised from among mankind, and retaining all human passions and appetites,"[2] were handed over the rule and governance of natural phenomena.

Tested by observation and reflection, these early notions failed in the long run to satisfy the more penetrating intellects of our race. Far in the depths of history we find men of exceptional power differentiating themselves from the crowd, rejecting these anthropomorphic notions, and seeking to connect natural phenomena with their physical principles. But, long prior to these purer efforts of the understanding, the merchant had been abroad, and rendered the philosopher possible; commerce had been developed, wealth amassed, leisure for travel and speculation secured, while races educated under different conditions, and therefore differently informed and endowed, had been stimulated and sharpened by mutual contact. In those regions where the commercial aristocracy of ancient Greece mingled with their eastern neighbours, the sciences were born, being nurtured and developed by free-thinking and courageous men. The state of things to be displaced may be gathered from a passage of Euripides quoted by Hume: "There is nothing in the world; no glory, no prosperity. The gods toss all into confusion; mix everything with its reverse, that all of us, from our ignorance and uncertainty, may pay them the more worship and reverence." Now, as science demands the radical extirpation of caprice and the absolute reliance upon law in nature, there grew, with the growth of scientific notions, a desire and determination to sweep from the field of theory

[1] Delivered before the British Association on Wednesday, August 19th, 1874.
[2] Hume, *Natural History of Religion*.

this mob of gods and demons, and to place natural phenomena on a basis more congruent with themselves.

The problem, which had been previously approached from above, was now attacked from below; theoretic effort passed from the super- to the sub-sensible. It was felt that, to construct the universe in idea, it was necessary to have some notion of its constituent parts—of what Lucretius subsequently called the "First Beginnings." Abstracting again from experience, the leaders of scientific speculation reached at length the pregnant doctrine of atoms and molecules, the latest developments of which were set forth with such power and clearness at the last meeting of the British Association. Thought, no doubt, had long hovered about this doctrine before it attained the precision and completeness which it assumed in the mind of Democritus,[1] a philosopher who may well for a moment arrest our attention. "Few great men," says Lange, a non-materialist, in his excellent *History of Materialism*, to the spirit and to the letter of which I am equally indebted, "have been so despitefully used by history as Democritus. In the distorted images sent down to us through unscientific traditions there remains of him almost nothing but the name of 'the laughing philosopher,' while figures of immeasurably smaller significance spread themselves out at full length before us." Lange speaks of Bacon's high appreciation of Democritus—for ample illustrations of which I am indebted to my excellent friend Mr. Spedding, the learned editor and biographer of Bacon. It is evident, indeed, that Bacon considered Democritus to be a man of weightier metal than either Plato or Aristotle, though their philosophy "was noised and celebrated in the schools, amid the din and pomp of professors." It was not they, but Genseric and Attila and the barbarians, who destroyed the atomic philosophy. "For, at a time when all human learning had suffered shipwreck, these planks of Aristotelian and Platonic philosophy, as being of a lighter and more inflated substance, were preserved and came down to us, while things more solid sank and almost passed into oblivion."

The son of a wealthy father, Democritus devoted the whole of his inherited fortune to the culture of his mind. He travelled everywhere; visited Athens when Socrates and Plato were there, but quitted the city without making himself known. Indeed, the dialectic strife in which Socrates so much delighted had no charm for Democritus, who held that "the man who readily contradicts, and uses many words, is unfit to learn anything truly right." He is said to have discovered and educated Protagoras the Sophist, being struck as much by the manner in which he, being a hewer of wood, tied up his faggots as by the sagacity of his conversation. Democritus returned poor from his travels, was supported by his brother, and at length wrote his great work entitled "Diakosmos," which he read publicly before the people of his native town. He was honoured by his countrymen in various ways, and died serenely at a great age.

The principles enunciated by Democritus reveal his uncompromising antagonism to those who deduced the phenomena of nature from the caprices of the gods. They are briefly these: 1. From nothing comes nothing. Nothing that exists can be destroyed. All changes are due to the combination and separation of molecules. 2. Nothing happens by chance; every occurrence has its cause, from which it follows by necessity. 3. The only existing things are the atoms and empty space; all else is mere opinion. 4. The atoms are infinite in number and infinitely various in form; they strike together, and the lateral motions and whirlings which thus arise are the beginnings of worlds. 5. The varieties of all things depend upon the varieties of their atoms, in number, size, and aggregation. 6. The soul consists of fine, smooth,

[1] Born 460 B.C.

round atoms, like those of fire. These are the most mobile of all: they interpenetrate the whole body, and in their motions the phenomena of life arise.

The first five propositions are a fair general statement of the atomic philosophy, as now held. As regards the sixth, Democritus made his finer atoms do duty for the nervous system, whose functions were then unknown. The atoms of Democritus are individually without sensation; they combine in obedience to mechanical laws; and not only organic forms, but the phenomena of sensation and thought, are the result of their combination.

That great enigma, "the exquisite adaptation of one part of an organism to another part, and to the conditions of life," more especially the construction of the human body, Democritus made no attempt to solve. Empedocles, a man of more fiery and poetic nature, introduced the notion of love and hate among the atoms to account for their combination and separation; and, bolder than Democritus, he struck in with the penetrating thought, linked, however, with some wild speculation, that it lay in the very nature of those combinations which were suited to their ends (in other words, in harmony with their environment) to maintain themselves, while unfit combinations, having no proper habitat, must rapidly disappear. Thus, more than 2,000 years ago, the doctrine of the "survival of the fittest," which in our day, not on the basis of vague conjecture, but of positive knowledge, has been raised to such extraordinary significance, had received at all events partial enunciation.[1]

Epicurus,[2] said to be the son of a poor schoolmaster at Samos, is the next dominant figure in the history of the atomic philosophy. He mastered the writings of Democritus, heard lectures in Athens, went back to Samos, and subsequently wandered through various countries. He finally returned to Athens, where he bought a garden and surrounded himself by pupils, in the midst of whom he lived a pure and serene life, and died a peaceful death. Democritus looked to the soul as the ennobling part of man; even beauty, without understanding, partook of animalism. Epicurus also rated the spirit above the body; the pleasure of the body being that of the moment, while the spirit could draw upon the future and the past. His philosophy was almost identical with that of Democritus; but he never quoted either friend or foe. One main object of Epicurus was to free the world from superstition and the fear of death. Death he treated with indifference. It merely robs us of sensation. As long as we are, death is not; and when death is, we are not. Life has no more evil for him who has made up his mind that it is no evil not to live. He adored the gods, but not in the ordinary fashion. The idea of Divine power, properly purified, he thought an elevating one. Still he taught: "Not he is godless who rejects the gods of the crowd, but rather he who accepts them." The gods were to him eternal and immortal beings, whose blessedness excluded every thought of care or occupation of any kind. Nature pursues her course in accordance with everlasting laws, the gods never interfering. They haunt

"The lucid interspace of world and world
Where never creeps a cloud or moves a wind,
Nor ever falls the least white star of snow,
Nor ever lowest roll of thunder moans,
Nor sound of human sorrow mounts to mar
Their sacred everlasting calm."[1]

Lange considers the relation of Epicurus to the gods subjective; the indication, probably, of an ethical requirement of his own nature. We cannot read history with open eyes, or study human nature to its depths, and fail to discern such a requirement. Man never has been, and he never will be, satisfied with the operations and products of the Understanding alone; hence physical

[1] See *Lange*, 2nd edit., p. 23. [2] Born 342 B.C.

[1] Tennyson's *Lucretius*.

science cannot cover all the demands of his nature. But the history of the efforts made to satisfy these demands might be broadly described as a history of errors —the error, in great part, consisting in ascribing fixity to that which is fluent, which varies as we vary, being gross when we are gross, and becoming, as our capacities widen, more abstract and sublime. On one great point the mind of Epicurus was at peace. He neither sought nor expected, here or hereafter, any personal profit from his relation to the gods. And it is assuredly a fact that loftiness and serenity of thought may be promoted by conceptions which involve no idea of profit of this kind. "Did I not believe," said a great man[1] to me once, "that an Intelligence is at the heart of things, my life on earth would be intolerable." The utterer of these words is not, in my opinion, rendered less but more noble by the fact that it was the need of ethical harmony here, and not the thought of personal happiness hereafter, that prompted his observation.

There are persons, not belonging to the highest intellectual zone, nor yet to the lowest, to whom perfect clearness of exposition suggests want of depth. They find comfort and edification in an abstract and learned phraseology. To such people Epicurus, who spared no pains to rid his style of every trace of haze and turbidity, appeared, on this very account, superficial. He had, however, a disciple who thought it no unworthy occupation to spend his days and nights in the effort to reach the clearness of his master, and to whom the Greek philosopher is mainly indebted for the extension and perpetuation of his fame. Some two centuries after the death of Epicurus, Lucretius[2] wrote his great poem, *On the Nature of Things*, in which he, a Roman, developed with extraordinary ardour the philosophy of his Greek predecessor. He wishes to win over his friend Memnius to the school of Epicurus; and although he has no rewards in a future life to offer, although his object appears to be a purely negative one, he addresses his friend with the heat of an apostle. His object, like that of his great forerunner, is the destruction of superstition; and considering that men in his day trembled before every natural event as a direct monition from the gods, and that everlasting torture was also in prospect, the freedom aimed at by Lucretius might be deemed a positive good. "This terror," he says, "and darkness of mind, must be dispelled, not by the rays of the sun and glittering shafts of day, but by the aspect and the law of nature." He refutes the notion that anything can come out of nothing, or that what is once begotten can be recalled to nothing. The first beginnings, the atoms, are indestructible, and into them all things can be resolved at last. Bodies are partly atoms and partly combinations of atoms; but the atoms nothing can quench. They are strong in solid singleness, and, by their denser combination, all things can be closely packed and exhibit enduring strength. He denies that matter is infinitely divisible. We come at length to the atoms, without which, as an imperishable substratum, all order in the generation and development of things would be destroyed.

The mechanical shock of the atoms being, in his view, the all-sufficient cause of things, he combats the notion that the constitution of nature has been in any way determined by intelligent design. The interaction of the atoms throughout infinite time rendered all manner of combinations possible. Of these, the fit ones persisted, while the unfit ones disappeared. Not after sage deliberation did the atoms station themselves in their right places, nor did they bargain what motions they should assume. From all eternity they have been driven together, and, after trying motions and unions of every kind, they fell at length into the arrangements, out of which this system of things has been evolved. "If you will apprehend and keep in mind these things, Nature, free at once and rid of

[1] Carlyle.

[2] Born 99 B.C.

her haughty lords, is seen to do all things spontaneously of herself, without the meddling of the gods."[1]

To meet the objection that his atoms cannot be seen, Lucretius describes a violent storm, and shows that the invisible particles of air act in the same way as the visible particles of water. We perceive, moreover, the different smells of things, yet never see them coming to our nostrils. Again, clothes hung up on a shore, which waves break upon, become moist, and then get dry if spread out in the sun, though no eye can see either the approach or the escape of the water-particles. A ring, worn long on the finger, becomes thinner; a water-drop hollows out a stone; the ploughshare is rubbed away in the field; the street-pavement is worn by the feet; but the particles that disappear at any moment we cannot see. Nature acts through invisible particles. That Lucretius had a strong scientific imagination the foregoing references prove. A fine illustration of his power in this respect is his explanation of the apparent rest of bodies whose atoms are in motion. He employs the image of a flock of sheep with skipping lambs, which, seen from a distance, presents simply a white patch upon the green hill, the jumping of the individual lambs being quite invisible.

His vaguely grand conception of the atoms falling eternally through space suggested the nebular hypothesis to Kant, its first propounder. Far beyond the limits of our visible world are to be found atoms innumerable, which have never been united to form bodies, or which, if once united, have been again dispersed—falling silently through immeasurable intervals of time and space. As everywhere throughout the All the same conditions are repeated, so must the phenomena be repeated also. Above us, below us, beside us, therefore, are worlds without end; and this, when considered, must dissipate every thought of a deflection of the universe by the gods. The worlds come and go, attracting new atoms out of limitless space, or dispersing their own particles. The reputed death of Lucretius, which forms the basis of Mr. Tennyson's noble poem, is in strict accordance with his philosophy, which was severe and pure.

§ 2.

STILL earlier than these three philosophers, and during the centuries between the first of them and the last, the human intellect was active in other fields than theirs. Pythagoras had founded a school of mathematics, and made his experiments on the harmonic intervals. The Sophists had run through their career. At Athens had appeared Socrates, Plato, and Aristotle, who ruined the Sophists, and whose yoke remains to some extent unbroken to the present hour. Within this period also the School of Alexandria was founded, Euclid wrote his *Elements*, and made some advance in optics. Archimedes had propounded the theory of the lever and the principles of hydrostatics. Astronomy was immensely enriched by the discoveries of Hipparchus, who was followed by the historically more celebrated Ptolemy. Anatomy had been made the basis of scientific medicine; and it is said by Draper[1] that vivisection had begun. In fact, the science of ancient Greece had already cleared the world of the fantastic images of divinities operating capriciously through natural phenomena. It had shaken itself free from that fruitless scrutiny "by the internal light of the mind alone," which had vainly sought to transcend experience, and to reach a knowledge of ultimate causes. Instead of accidental observation, it had introduced observation with a purpose; instruments were employed to aid the senses, and scientific

[1] Monro's translation. In his criticism of this work (*Contemporary Review*, 1867) Dr. Hayman does not appear to be aware of the really sound and subtile observations on which the reasoning of Lucretius, though erroneous, sometimes rests.

[1] *History of the Intellectual Development of Europe*, p. 295.

method was rendered in a great measure complete by the union of Induction and Experiment.

What, then, stopped its victorious advance? Why was the scientific intellect compelled, like an exhausted soil, to lie fallow for nearly two millenniums, before it could regather the elements necessary to its fertility and strength? Bacon has already let us know one cause; Whewell ascribes this stationary period to four causes—obscurity of thought, servility, intolerance of disposition, enthusiasm of temper; and he gives striking examples of each.[1] But these characteristics must have had their antecedents in the circumstances of the time. Rome, and the other cities of the Empire, had fallen into moral putrefaction. Christianity had appeared, offering the Gospel to the poor, and by moderation, if not asceticism of life, practically protesting against the profligacy of the age. The sufferings of the early Christians, and the extraordinary exaltation of mind which enabled them to triumph over the diabolical tortures to which they were subjected,[2] must have left traces not easily effaced. They scorned the earth, in view of that "building of God, that house not made with hands, eternal in the heavens." The Scriptures which ministered to their spiritual needs were also the measure of their science. When, for example, the celebrated question of Antipodes came to be discussed, the Bible was with many the ultimate court of appeal. Augustine, who flourished A.D. 400, would not deny the rotundity of the earth; but he would deny the possible existence of inhabitants at the other side, "because no such race is recorded in Scripture among the descendants of Adam." Archbishop Boniface was shocked at the assumption of a "world of human beings out of the reach of the means of salvation." Thus reined in, Science was not likely to make much progress. Later on, the political and theological strife between the Church and civil governments, so powerfully depicted by Draper, must have done much to stifle investigation.

Whewell makes many wise and brave remarks regarding the spirit of the Middle Ages. It was a menial spirit. The seekers after natural knowledge had forsaken the fountain of living waters, the direct appeal to nature by observation and experiment, and given themselves up to the remanipulation of the notions of their predecessors. It was a time when thought had become abject, and when the acceptance of mere authority led, as it always does in science, to intellectual death. Natural events, instead of being traced to physical, were referred to moral, causes; while an exercise of the phantasy, almost as degrading as the spiritualism of the present day, took the place of scientific speculation. Then came the mysticism of the Middle Ages, Magic, Alchemy, the Neoplatonic philosophy, with its visionary though sublime abstractions, which caused men to look with shame upon their own bodies, as hindrances to the absorption of the creature in the blessedness of the Creator. Finally came the scholastic philosophy, a fusion, according to Lange, of the least mature notions of Aristotle with the Christianity of the West. Intellectual immobility was the result. As a traveller without a compass in a fog may wander long, imagining he is making way, and find himself after hours of toil at his starting-point, so the schoolmen, having "tied and untied the same knots, and formed and dissipated the same clouds,"[1] found themselves at the end of centuries in their old position.

With regard to the influence wielded by Aristotle in the Middle Ages, and which, to a less extent, he still wields, I would ask permission to make one remark. When the human mind has achieved greatness and given evidence of extraordinary power in one domain, there is a tendency to credit it with

[1] *History of the Inductive Sciences*, vol. i.

[2] Described with terrible vividness in Renan's *Antichrist*.

[1] Whewell.

similar power in all other domains. Thus theologians have found comfort and assurance in the thought that Newton dealt with the question of revelation—forgetful of the fact that the very devotion of his powers, through all the best years of his life, to a totally different class of ideas, not to speak of any natural disqualification, tended to render him less, instead of more, competent to deal with theological and historic questions. Goethe, starting from his established greatness as a poet, and indeed from his positive discoveries in Natural History, produced a profound impression among the painters of Germany, when he published his "Farbenlehre," in which he endeavoured to overthrow Newton's theory of colours. This theory he deemed so obviously absurd that he considered its author a charlatan, and attacked him with a corresponding vehemence of language. In the domain of Natural History Goethe had made really considerable discoveries; and we have high authority for assuming that, had he devoted himself wholly to that side of science, he might have reached an eminence comparable with that which he attained as a poet. In sharpness of observation, in the detection of analogies apparently remote, in the classification and organisation of facts according to the analogies discerned, Goethe possessed extraordinary powers. These elements of scientific inquiry fall in with the disciplines of the poet. But, on the other hand, a mind thus richly endowed in the direction of Natural History may be almost shorn of endowment as regards the physical and mechanical sciences. Goethe was in this condition. He could not formulate distinct mechanical conceptions; he could not see the force of mechanical reasoning; and, in regions where such reasoning reigns supreme, he became a mere *ignis fatuus* to those who followed him.

I have sometimes permitted myself to compare Aristotle with Goethe—to credit the Stagirite with an almost superhuman power of amassing and systematising facts, but to consider him fatally defective on that side of the mind in respect to which incompleteness has been just ascribed to Goethe. Whewell refers the errors of Aristotle not to a neglect of facts, but to "a neglect of the idea appropriate to the facts; the idea of Mechanical cause, which is Force, and the substitution of vague or inapplicable notions, involving only relations of space or emotions of wonder." This is doubtless true; but the word "neglect" implies mere intellectual misdirection, whereas in Aristotle, as in Goethe, it was not, I believe, misdirection, but sheer natural incapacity, which lay at the root of his mistakes. As a physicist, Aristotle displayed what we should consider some of the worst of attributes in a modern physical investigator—indistinctness of ideas, confusion of mind, and a confident use of language which led to the delusive notion that he had really mastered his subject, while he had, as yet, failed to grasp even the elements of it. He put words in the place of things, subject in the place of object. He preached Induction without practising it, inverting the true order of inquiry by passing from the general to the particular, instead of from the particular to the general. He made of the universe a closed sphere, in the centre of which he fixed the earth, proving from general principles, to his own satisfaction and to that of the world for near 2,000 years, that no other universe was possible. His notions of motion were entirely unphysical. It was natural or unnatural, better or worse, calm or violent—no real mechanical conception regarding it lying at the bottom of his mind. He affirmed that a vacuum could not exist, and proved that if it did motion in it would be impossible. He determined *à priori* how many species of animals must exist, and showed on general principles why animals must have such and such parts. When an eminent contemporary philosopher, who is far removed from errors of this kind, remembers these abuses of the *à priori* method, he will be able to make allowance for the

jealousy of physicists as to the acceptance of so-called *à priori* truths. Aristotle's errors of detail, as shown by Eucken and Lange, were grave and numerous. He affirmed that only in man we had the beating of the heart, that the left side of the body was colder than the right, that men have more teeth than women, and that there is an empty space at the back of every man's head.

There is one essential quality in physical conceptions which was entirely wanting in those of Aristotle and his followers—a capability of being placed as coherent pictures before the mind. The Germans express the act of picturing by the word *vorstellen*, and the picture they call a *Vorstellung*. We have no word in English which comes nearer to our requirements than *Imagination*; and, taken with its proper limitations, the word answers very well. But it is tainted by its associations, and therefore objectionable to some minds. Compare, with reference to this capacity of mental presentation, the case of the Aristotelian, who refers the ascent of water in a pump to Nature's abhorrence of a vacuum, with that of Pascal when he proposed to solve the question of atmospheric pressure by the ascent of the Puy de Dôme. In the one case the terms of the explanation refuse to fall into place as a physical image; in the other the image is distinct, the descent and rise of the barometer being clearly figured beforehand as the balancing of two varying and opposing pressures.

§ 3.

During the drought of the Middle Ages in Christendom, the Arabian intellect, as forcibly shown by Draper, was active. With the intrusion of the Moors into Spain, order, learning, and refinement took the place of their opposites. When smitten with disease, the Christian peasant resorted to a shrine, the Moorish one to an instructed physician. The Arabs encouraged translations from the Greek philosophers, but not from the Greek poets. They turned in disgust "from the lewdness of our classical mythology, and denounced as an unpardonable blasphemy all connection between the impure Olympian Jove and the Most High God." Draper traces still farther than Whewell the Arab elements in our scientific terms. He gives examples of what Arabian men of science accomplished, dwelling particularly on Alhazen, who was the first to correct the Platonic notion that rays of light are emitted by the eye. Alhazen discovered atmospheric refraction, and showed that we see the sun and the moon after they have set. He explained the enlargement of the sun and moon, and the shortening of the vertical diameters of both these bodies when near the horizon. He was aware that the atmosphere decreases in density with increase of elevation, and actually fixed its height at 58½ miles. In the *Book of the Balance of Wisdom* he sets forth the connection between the weight of the atmosphere and its increasing density. He shows that a body will weigh differently in a rare and dense atmosphere, and he considers the force with which plunged bodies rise through heavier media. He understood the doctrine of the centre of gravity, and applied it to the investigation of balances and steelyards. He recognised gravity as a force, though he fell into the error of assuming it to diminish simply as the distance, and of making it purely terrestrial. He knew the relation between the velocities, spaces, and times of falling bodies, and had distinct ideas of capillary attraction. He improved the hydrometer. The determinations of the densities of bodies, as given by Alhazen, approach very closely to our own. "I join," says Draper, "in the pious prayer of Alhazen, that in the day of judgment the All-Merciful will take pity on the soul of Abur-Raihân, because he was the first of the race of men to construct a table of specific gravities." If all this be historic truth (and I have entire confidence in Dr. Draper), well may he "deplore the

systematic manner in which the literature of Europe has contrived to put out of sight our scientific obligations to the Mohammedans."[1]

The strain upon the mind during the stationary period towards ultra-terrestrial things, to the neglect of problems close at hand, was sure to provoke reaction. But the reaction was gradual; for the ground was dangerous, and a power was at hand competent to crush the critic who went too far. To elude this power, and still allow opportunity for the expression of opinion, the doctrine of "twofold truth" was invented, according to which an opinion might be held "theologically," and the opposite opinion "philosophically."[2] Thus, in the thirteenth century, the creation of the world in six days, and the unchangeableness of the individual soul, which had been so distinctly affirmed by St. Thomas Aquinas, were both denied philosophically, but admitted to be true as articles of the Catholic faith. When Protagoras uttered the maxim which brought upon him so much vituperation, that "opposite assertions are equally true," he simply meant to affirm men's differences to be so great that what was subjectively true to the one might be subjectively untrue to the other. The great Sophist never meant to play fast and loose with the truth by saying that one of two opposite assertions, made by the same individual, could possibly escape being a lie. It was not "sophistry," but the dread of theologic vengeance, that generated this double dealing with conviction; and it is astonishing to notice what lengths were allowed to men who were adroit in the use of artifices of this kind.

Towards the close of the stationary period a word-weariness, if I may so express it, took more and more possession of men's minds. Christendom had become sick of the School Philosophy and its verbal wastes, which led to no issue, but left the intellect in everlasting haze. Here and there was heard the voice of one impatiently crying in the wilderness: "Not unto Aristotle, not unto subtle hypothesis, not unto church, Bible, or blind tradition, must we turn for a knowledge of the universe, but to the direct investigation of nature by observation and experiment." In 1543 the epoch-marking work of Copernicus on the paths of the heavenly bodies appeared. The total crash of Aristotle's closed universe, with the earth at its centre, followed as a consequence, and "The earth moves!" became a kind of watchword among intellectual freemen. Copernicus was Canon of the church of Frauenburg in the diocese of Ermeland. For three-and-thirty years he had withdrawn himself from the world, and devoted himself to the consolidation of his great scheme of the solar system. He made its blocks eternal; and even to those who feared it, and desired its overthrow, it was so obviously strong that they refrained for a time from meddling with it. In the last year of the life of Copernicus his book appeared; it is said that the old man received a copy of it a few days before his death, and then departed in peace.

The Italian philosopher, Giordano Bruno, was one of the earliest converts to the new astronomy. Taking Lucretius as his exemplar, he revived the notion of the infinity of worlds; and, combining with it the doctrine of Copernicus, reached the sublime generalisation that the fixed stars are suns, scattered numberless through space, and accompanied by satellites, which bear the same relation to them that our earth does to our sun, or our moon to our earth. This was an expansion of transcendent import; but Bruno came closer than this to our present line of thought. Struck with the problem of the generation and maintenance of organisms, and duly pondering it, he came to the conclusion that Nature, in her productions, does not imitate the technic of man. Her process is one of unravelling and unfolding.

[1] *Intellectual Development of Europe*, p. 359.
[2] *Lange*, 2nd edit., pp. 181, 182.

The infinity of forms under which matter appears was not imposed upon it by an external artificer; by its own intrinsic force and virtue it brings these forms forth. Matter is not the mere naked empty *capacity* which philosophers have pictured her to be, but the universal mother, who brings forth all things as the fruit of her own womb.

This outspoken man was originally a Dominican monk. He was accused of heresy and had to fly, seeking refuge in Geneva, Paris, England, and Germany. In 1592 he fell into the hands of the Inquisition at Venice. He was imprisoned for many years, tried, degraded, excommunicated, and handed over to the civil power, with the request that he should be treated gently, and "without the shedding of blood." This meant that he was to be burnt; and burnt accordingly he was, on February 16th, 1600. To escape a similar fate Galileo, thirty-three years afterwards, abjured upon his knees, with his hands upon the holy Gospels, the heliocentric doctrine, which he knew to be true. After Galileo came Kepler, who from his German home defied the ultramontane power. He traced out from pre-existing observations the laws of planetary motion. Materials were thus prepared for Newton, who bound those empirical laws together by the principle of gravitation.

§ 4.

In the seventeenth century Bacon and Descartes, the restorers of philosophy, appeared in succession. Differently educated and endowed, their philosophic tendencies were different. Bacon held fast to Induction, believing firmly in the existence of an external world, and making collected experiences the basis of all knowledge. The mathematical studies of Descartes gave him a bias towards Deduction; and his fundamental principle was much the same as that of Protagoras, who made the individual man the measure of all things. "I think, therefore I am," said Descartes. Only his own identity was sure to him; and the full development of this system would have led to an idealism, in which the outer world would have been resolved into a mere phenomenon of consciousness. Gassendi, one of Descartes's contemporaries, of whom we shall hear more presently, quickly pointed out that the fact of personal existence would be proved as well by reference to any other act as to the act of thinking. I eat, therefore I am, or I love, therefore I am, would be quite as conclusive. Lichtenberg, indeed, showed that the very thing to be proved was inevitably postulated in the first two words, "I think"; and it is plain that no inference from the postulate could, by any possibility, be stronger than the postulate itself.

But Descartes deviated strangely from the idealism implied in his fundamental principle. He was the first to reduce, in a manner eminently capable of bearing the test of mental presentation, vital phenomena to purely mechanical principles. Through fear or love, Descartes was a good Churchman; he accordingly rejected the notion of an atom, because it was absurd to suppose that God, if He so pleased, could not divide an atom; he puts in the place of the atoms small round particles, and light splinters, out of which he builds the organism. He sketches with marvellous physical insight a machine, with water for its motive power, which shall illustrate vital actions. He has made clear to his mind that such a machine would be competent to carry on the processes of digestion, nutrition, growth, respiration, and the beating of the heart. It would be competent to accept impressions from the external sense, to store them up in imagination and memory, to go through the internal movements of the appetites and passions, and the external movements of the limbs. He deduces these functions of his machine from the mere arrangement of its organs, as the movement of a clock, or other automaton, is deduced from its weights and wheels. "As far as these functions are concerned," he says, "it is

not necessary to conceive any other vegetative or sensitive soul, nor any other principle of motion or of life, than the blood and the spirits agitated by the fire which burns continually in the heart, and which is in nowise different from the fires existing in inanimate bodies." Had Descartes been acquainted with the steam-engine, he would have taken it, instead of a fall of water, as his motive power. He would have shown the perfect analogy which exists between the oxidation of the food in the body and that of the coal in the furnace. He would assuredly have anticipated Mayer in calling the blood, which the heart diffuses, "the oil of the lamp of life," deducing all animal motions from the combustion of this oil, as the motions of a steam-engine are deduced from the combustion of its coal. As the matter stands, however, and considering the circumstances of the time, the boldness, clearness, and precision with which Descartes grasped the problem of vital dynamics constitute a marvellous illustration of intellectual power.[1]

During the Middle Ages the doctrine of atoms had to all appearance vanished from discussion. It probably held its ground among sober-minded and thoughtful men, though neither the church nor the world was prepared to hear of it with tolerance. Once, in the year 1348, it received distinct expression. But retractation by compulsion immediately followed; and, thus discouraged, it slumbered till the seventeenth century, when it was revived by a contemporary and friend of Hobbes of Malmesbury, the orthodox Catholic provost of Digne, Gassendi. But, before stating his relation to the Epicurean doctrine, it will be well to say a few words on the effect, as regards science, of the general introduction of monotheism among European nations.

"Were men," says Hume, "led into the apprehension of invisible intelligent power by contemplation of the works of Nature, they could never possibly entertain any conception but of one single Being, who bestowed existence and order on this vast machine, and adjusted all its parts to one regular system." Referring to the condition of the heathen, who sees a god behind every natural event, thus peopling the world with thousands of beings whose caprices are incalculable, Lange shows the impossibility of any compromise between such notions and those of science, which proceeds on the assumption of never-changing law and causality. "But," he continues, with characteristic penetration, "when the great thought of one God, acting as a unit upon the universe, has been seized, the connection of things in accordance with the law of cause and effect is not only thinkable, but it is a necessary consequence of the assumption. For when I see ten thousand wheels in motion, and know, or believe, that they are all driven by one motive power, then I know that I have before me a mechanism, the action of every part of which is determined by the plan of the whole. So much being assumed, it follows that I may investigate the structure of that machine, and the various motions of its parts. For the time being, therefore, this conception renders scientific action free." In other words, were a capricious god at the circumference of every wheel and at the end of every lever, the action of the machine would be incalculable by the methods of science. But the actions of all its parts being rigidly determined by their connections and relations, and these being brought into play by a single motive power, then, though this last prime mover may elude me, I am still able to comprehend the machinery which it sets in motion. We have here a conception of the relation of Nature to its Author, which seems perfectly acceptable to some minds, but perfectly intolerable to others. Newton and Boyle lived and worked happily under the influence of this conception; Goethe rejected it with vehemence, and the same

[1] See Huxley's admirable *Essay on Descartes. Lay Sermons*, pp. 364, 365.

repugnance to accepting it is manifest in Carlyle.[1]

The analytic and synthetic tendencies of the human mind are traceable throughout history, great writers ranging themselves sometimes on the one side, sometimes on the other. Men of warm feelings, and minds open to the elevating impressions produced by nature as a whole, whose satisfaction, therefore, is rather ethical than logical, lean to the synthetic side; while the analytic harmonises best with the more precise and more mechanical bias which seeks the satisfaction of the understanding. Some form of pantheism was usually adopted by the one, while a detached Creator, working more or less after the manner of men, was often assumed by the other. Gassendi, as sketched by Lange, is hardly to be ranked with either. Having formally acknowledged God as the great first cause, he immediately dropped the idea, applied the known laws of mechanics to the atoms, and deduced from them all vital phenomena. He defended Epicurus, and dwelt upon his purity, both of doctrine and of life. True he was a heathen, but so was Aristotle. Epicurus assailed superstition and religion, and rightly, because he did not know the true religion. He thought that the gods neither rewarded nor punished, and he adored them purely in consequence of their completeness: here we see, says Gassendi, the reverence of the child, instead of the fear of the slave. The errors of Epicurus shall be corrected, and the body of his truth retained. Gassendi then proceeds, as any heathen might have done, to build up the world, and all that therein is, of atoms and molecules. God, who created earth and water, plants and animals, produced in the first place a definite number of atoms, which constituted the seed of all things. Then began that series of combinations and decompositions which now goes on, and which will continue in future. The principle of every change resides in matter. In artificial productions the moving principle is different from the material worked upon; but in nature the agent works within, being the most active and mobile part of the material itself. Thus this bold ecclesiastic, without incurring the censure of the Church or the world, contrives to outstrip Mr. Darwin. The same cast of mind which caused him to detach the Creator from his universe led him also to detach the soul from the body, though to the body he ascribes an influence so large as to render the soul almost unnecessary. The aberrations of reason were, in his view, an affair of the material brain. Mental disease is brain-disease; but then the immortal reason sits apart, and cannot be touched by the disease. The errors of madness are those of the instrument, not of the performer.

It may be more than a mere result of education, connecting itself, probably, with the deeper mental structure of the two men, that the idea of Gassendi, above enunciated, is substantially the same as that expressed by Professor Clerk Maxwell, at the close of the very able lecture delivered by him at Bradford in 1873. According to both philosophers, the atoms, if I understand aright, are *prepared materials*, which, formed once for all by the Eternal, produce by their subsequent interaction all the phenomena of the material world. There seems to be this difference, however, between Gassendi and Maxwell. The one *postulates*, the other *infers*, his first cause. In his "manufactured articles," as he calls the atoms, Professor Maxwell finds the basis of an induction which enables him to scale philosophic heights considered inaccessible by Kant, and to take the logical step from the atoms to their Maker.

Accepting here the leadership of Kant, I doubt the legitimacy of Maxwell's

[1] Boyle's model of the universe was the Strasburg clock with an outside Artificer. Goethe, on the other hand, sang:—

> "Ihm ziemt's die Welt im Innern zu bewegen,
> Natur in sich, sich in Natur zu hegen."

See also Carlyle, *Past and Present*, chap. v.

logic; but it is impossible not to feel the ethic glow with which his lecture concludes. There is, moreover, a very noble strain of eloquence in his description of the steadfastness of the atoms: "Natural causes, as we know, are at work, which tend to modify, if they do not at length destroy, all the arrangements and dimensions of the earth and the whole solar system. But though in the course of ages catastrophes have occurred and may yet occur in the heavens, though ancient systems may be dissolved and new systems evolved out of their ruins, the molecules out of which these systems are built—the foundation stones of the material universe—remain unbroken and unworn."

The atomic doctrine, in whole or in part, was entertained by Bacon, Descartes, Hobbes, Locke, Newton, Boyle, and their successors, until the chemical law of multiple proportions enabled Dalton to confer upon it an entirely new significance. In our day there are secessions from the theory, but it still stands firm. Loschmidt, Stoney, and Sir William Thomson have sought to determine the sizes of the atoms, or rather to fix the limits between which their sizes lie; while the discourses of Williamson and Maxwell delivered in Bradford in 1873 illustrate the present hold of the doctrine upon the foremost scientific minds. In fact, it may be doubted whether, wanting this fundamental conception, a theory of the material universe is capable of scientific statement.

§ 5.

NINETY years subsequent to Gassendi the doctrine of bodily instruments, as it may be called, assumed immense importance in the hands of Bishop Butler, who, in his famous *Analogy of Religion*, developed, from his own point of view, and with consummate sagacity, a similar idea. The Bishop still influences many superior minds; and it will repay us to dwell for a moment on his views. He draws the sharpest distinction between our real selves and our bodily instruments. He does not, as far as I remember, use the word "soul," possibly because the term was so hackneyed in his day, as it had been for many generations previously. But he speaks of "living powers," "perceiving or percipient powers," "moving agents," "ourselves," in the same sense as we should employ the term "soul." He dwells upon the fact that limbs may be removed, and mortal diseases assail the body, the mind, almost up to the moment of death, remaining clear. He refers to sleep and to swoon, where the "living powers" are suspended but not destroyed. He considers it quite as easy to conceive of existence out of our bodies as in them; that we may animate a succession of bodies, the dissolution of all of them having no more tendency to dissolve our real selves, or "deprive us of living faculties—the faculties of perception and action—than the dissolution of any foreign matter which we are capable of receiving impressions from, or making use of for the common occasions of life." This is the key of the Bishop's position: "our organised bodies are no more a part of ourselves than any other matter around us." In proof of this he calls attention to the use of glasses, which "prepare objects" for the "percipient power" exactly as the eye does. The eye itself is no more percipient than the glass; is quite as much the instrument of the true self, and also as foreign to the true self, as the glass is. "And if we see with our eyes only in the same manner as we do with glasses, the like may justly be concluded from analogy of all our senses."

Lucretius, as you are aware, reached a precisely opposite conclusion: and it certainly would be interesting, if not profitable, to us all to hear what he would or could urge in opposition to the reasoning of the Bishop. As a brief discussion of the point will enable us to see the bearings of an important question, I will here permit a disciple of Lucretius

to try the strength of the Bishop's position, and then allow the Bishop to retaliate, with the view of rolling back, if he can, the difficulty upon Lucretius.

The argument might proceed in this fashion:—

"Subjected to the test of mental presentation (*Vorstellung*), your views, most honoured prelate, would offer to many minds a great, if not an insuperable, difficulty. You speak of 'living powers,' 'percipient or perceiving powers,' and 'ourselves'; but can you form a mental picture of any of these, apart from the organism through which it is supposed to act? Test yourself honestly, and see whether you possess any faculty that would enable you to form such a conception. The true self has a local habitation in each of us; thus localised, must it not possess a form? If so, what form? Have you ever for a moment realised it? When a leg is amputated the body is divided into two parts; is the true self in both of them or in one? Thomas Aquinas might say in both; but not you, for you appeal to the consciousness associated with one of the two parts, to prove that the other is foreign matter. Is consciousness, then, a necessary element of the true self? If so, what do you say to the case of the whole body being deprived of consciousness? If not, then on what grounds do you deny any portion of the true self to the severed limb? It seems very singular that, from the beginning to the end of your admirable book (and no one admires its sober strength more than I do), you never once mention the brain or nervous system. You begin at one end of the body, and show that its parts may be removed without prejudice to the perceiving power. What if you begin at the other end, and remove, instead of the leg, the brain? The body, as before, is divided into two parts; but both are now in the same predicament, and neither can be appealed to to prove that the other is foreign matter. Or, instead of going so far as to remove the brain itself, let a certain portion of its bony covering be removed, and let a rhythmic series of pressures and relaxations of pressure be applied to the soft substance. At every pressure 'the faculties of perception and of action' vanish; at every relaxation of pressure they are restored. Where, during the intervals of pressure, is the perceiving power? I once had the discharge of a large Leyden battery passed unexpectedly through me: I felt nothing, but was simply blotted out of conscious existence for a sensible interval. Where was my true self during that interval? Men who have recovered from lightning-stroke have been much longer in the same state; and, indeed, in cases of ordinary concussion of the brain, days may elapse during which no experience is registered in consciousness. Where is the man himself during the period of insensibility? You may say that I beg the question when I assume the man to have been unconscious, that he was really conscious all the time, and has simply forgotten what had occurred to him. In reply to this, I can only say that no one need shrink from the worst tortures that superstition ever invented, if only so felt and so remembered. I do not think your theory of instruments goes at all to the bottom of the matter. A telegraph-operator has his instruments, by means of which he converses with the world; our bodies possess a nervous system, which plays a similar part between the perceiving power and external things. Cut the wires of the operator, break his battery, demagnetise his needle; by this means you certainly sever his connection with the world; but, inasmuch as these are real instruments, their destruction does not touch the man who uses them. The operator survives, *and he knows that he survives*. What is there, I would ask, in the human system that answers to this conscious survival of the operator when the battery of the brain is so disturbed as to produce insensibility, or when it is destroyed altogether?

"Another consideration, which you may regard as slight, presses upon me with some force. The brain may change from health to disease, and through such

a change the most exemplary man may be converted into a debauchee or a murderer. My very noble and approved good master had, as you know, threatenings of lewdness introduced into his brain by his jealous wife's philter; and sooner than permit himself to run even the risk of yielding to these base promptings he slew himself. How could the hand of Lucretius have been thus turned against himself if the real Lucretius remained as before? Can the brain or can it not act in this distempered way without the intervention of the immortal reason? If it can, then it is a prime mover which requires only healthy regulation to render it reasonably self-acting, and there is no apparent need of your immortal reason at all. If it cannot, then the immortal reason, by its mischievous activity in operating upon a broken instrument, must have the credit of committing every imaginable extravagance and crime. I think, if you will allow me to say so, that the gravest consequences are likely to flow from your estimate of the body. To regard the brain as you would a staff or an eyeglass—to shut your eyes to all its mystery, to the perfect correlation of its condition and our consciousness, to the fact that a slight excess or defect of blood in it produces the very swoon to which you refer, and that in relation to it our meat, and drink, and air, and exercise have a perfectly transcendental value and significance—to forget all this does, I think, open a way to innumerable errors in our habits of life, and may possibly, in some cases, initiate and foster that very disease, and consequent mental ruin, which a wiser appreciation of this mysterious organ would have avoided."

I can imagine the Bishop thoughtful after hearing this argument. He was not the man to allow anger to mingle with the consideration of a point of this kind. After due reflection, and having strengthened himself by that honest contemplation of the facts which was habitual with him, and which includes the desire to give even adverse reasonings their due weight, I can suppose the Bishop to proceed thus: "You will remember that in the *Analogy of Religion*, of which you have so kindly spoken, I did not profess to prove anything absolutely, and that I over and over again acknowledged and insisted on the smallness of our knowledge, or rather the depth of our ignorance, as regards the whole system of the universe. My object was, to show my deistical friends, who set forth so eloquently the beauty and beneficence of Nature and the Ruler thereof, while they had nothing but scorn for the so-called absurdities of the Christian scheme, that they were in no better condition than we were, and that, for every difficulty found upon our side, quite as great a difficulty was to be found upon theirs. I will now, with your permission, adopt a similar line of argument. You are a Lucretian, and from the combination and separation of insensate atoms deduce all terrestrial things, including organic forms and their phenomena. Let me tell you in the first instance how far I am prepared to go with you. I admit that you can build crystalline forms out of this play of molecular force; that the diamond, amethyst, and snow-star are truly wonderful structures which are thus produced. I will go farther, and acknowledge that even a tree or flower might in this way be organised. Nay, if you can show me an animal without sensation, I will concede to you that it also might be put together by the suitable play of molecular force.

"Thus far our way is clear, but now comes my difficulty. Your atoms are individually without sensation; much more are they without intelligence. May I ask you, then, to try your hand upon this problem? Take your dead hydrogen atoms, your dead oxygen atoms, your dead carbon atoms, your dead nitrogen atoms, your dead phosphorus atoms, and all the other atoms, dead as grains of shot, of which the brain is formed. Imagine them separate and sensationless; observe them running together and

forming all imaginable combinations. This, as a purely mechanical process, is *seeable* by the mind. But can you see, or dream, or in any way imagine, how out of that mechanical act, and from these individually dead atoms, sensation, thought, and emotion are to rise? Are you likely to extract Homer out of the rattling of dice, or the Differential Calculus out of the clash of billiard-balls? I am not all bereft of this *Vorstellungs-Kraft* of which you speak, nor am I, like so many of my brethren, a mere vacuum as regards scientific knowledge. I can follow a particle of musk until it reaches the olfactory nerve; I can follow the waves of sound until their tremors reach the water of the labyrinth, and set the otoliths and Corti's fibres in motion; I can also visualise the waves of ether as they cross the eye and hit the retina. Nay more, I am able to pursue to the central organ the motion thus imparted at the periphery, and to see in idea the very molecules of the brain thrown into tremors. My insight is not baffled by these physical processes. What baffles and bewilders me is the notion that from those physical tremors things so utterly incongruous with them as sensation, thought, and emotion can be derived. You may say, or think, that this issue of consciousness from the clash of atoms is not more incongruous than the flash of light from the union of oxygen and hydrogen. But I beg to say that it is. For such incongruity as the flash possesses is that which I now force upon your attention. The 'flash' is an affair of consciousness, the objective counterpart of which is a vibration. It is a flash only by your interpretation. *You* are the cause of the apparent incongruity; and *you* are the thing that puzzles me. I need not remind you that the great Leibnitz felt the difficulty which I feel; and that to get rid of this monstrous deduction of life from death he displaced your atoms by his monads, which were more or less perfect mirrors of the universe, and out of the summation and integration of which he supposed all the phenomena of life—sentient, intellectual, and emotional—to arise.

"Your difficulty then, as I see you are ready to admit, is quite as great as mine. You cannot satisfy the human understanding in its demand for logical continuity between molecular processes and the phenomena of consciousness. This is a rock on which Materialism must inevitably split whenever it pretends to be a complete philosophy of life. What is the moral, my Lucretian? You and I are not likely to indulge in ill-temper in the discussion of these great topics, where we see so much room for honest differences of opinion. But there are people of less wit or more bigotry (I say it with humility), on both sides, who are ever ready to mingle anger and vituperation with such discussions. There are, for example, writers of note and influence at the present day who are not ashamed publicly to assume the 'deep personal sin' of a great logician to be the cause of his unbelief in a theologic dogma.[1] And there are others who hold that we, who cherish our noble Bible, wrought as it has been into the constitution of our forefathers, and by inheritance into us, must necessarily be hypocritical and insincere. Let us disavow and discountenace such people, cherishing the unswerving faith that what is good and true in both our arguments will be preserved for the benefit of humanity, while all that is bad or false will disappear."

I hold the Bishop's reasoning to be unanswerable, and his liberality to be worthy of imitation.

It is worth remarking that in one respect the Bishop was a product of his age. Long previous to his day the nature

[1] This is the aspect under which the late Editor of the *Dublin Review* presented to his readers the memory of John Stuart Mill. I can only say that I would as soon take my chance in the other world, in the company of the "unbeliever," as in that of his Jesuit detractor. In Dr. Ward we have an example of a wholesome and vigorous nature soured and perverted by a poisonous creed.

of the soul had been so favourite and general a topic of discussion that, when the students of the Italian Universities wished to know the leanings of a new Professor, they at once requested him to lecture upon the soul. About the time of Bishop Butler the question was not only agitated but extended. It was seen by the clear-witted men who entered this arena that many of their best arguments applied equally to brutes and men. The Bishop's arguments were of this character. He saw it, admitted it, took the consequence, and boldly embraced the whole animal world in his scheme of immortality.

§ 6.

BISHOP BUTLER accepted with unwavering trust the chronology of the Old Testament, describing it as "confirmed by the natural and civil history of the world, collected from common historians, from the state of the earth, and from the late inventions of arts and sciences." These words mark progress; and they must seem somewhat hoary to the Bishop's successors of to-day. It is hardly necessary to inform you that since his time the domain of the naturalist has been immensely extended—the whole science of geology, with its astounding revelations regarding the life of the ancient earth, having been created. The rigidity of old conceptions has been relaxed, the public mind being rendered gradually tolerant of the idea that not for six thousand, nor for sixty thousand, nor for six thousand thousand, but for æons embracing untold millions of years, this earth has been the theatre of life and death. The riddle of the rocks has been read by the geologist and palæontologist from subcambrian depths to the deposits thickening over the sea-bottoms of to-day. And upon the leaves of that stone book are, as you know, stamped the characters, plainer and surer than those formed by the ink of history, which carry the mind back into abysses of past time, compared with which the periods which satisfied Bishop Butler cease to have a visual angle.

The lode of discovery once struck, those petrified forms in which life was at one time active increased to multitudes and demanded classification. They were grouped in genera, species, and varieties, according to the degree of similarity subsisting between them. Thus confusion was avoided, each object being found in the pigeon-hole appropriated to it and to its fellows of similar morphological or physiological character. The general fact soon became evident that none but the simplest forms of life lie lowest down; that, as we climb higher among the superimposed strata, more perfect forms appear. The change, however, from form to form was not continuous, but by steps—some small, some great. "A section," says Mr. Huxley, "a hundred feet thick will exhibit at different heights a dozen species of Ammonite, none of which passes beyond the particular zone of limestone, or clay, into the zone below it, or into that above it." In the presence of such facts it was not possible to avoid the question: Have these forms, showing, though in broken stages, and with many irregularities, this unmistakable general advance, been subjected to no continuous law of growth or variation? Had our education been purely scientific, or had it been sufficiently detached from influences which, however ennobling in another domain, have always proved hindrances and delusions when introduced as factors into the domain of physics, the scientific mind never could have swerved from the search for a law of growth, or allowed itself to accept the anthropomorphism which regarded each successive stratum as a kind of mechanic's bench for the manufacture of new species out of all relation to the old.

Biassed, however, by their previous education, the great majority of naturalists invoked a special creative act to account for the appearance of each new group of organisms. Doubtless numbers of them were clear-headed enough to see that this was no explanation at all—that, in point of fact, it was an attempt, by the introduction of a greater difficulty, to

account for a less. But, having nothing to offer in the way of explanation, they for the most part held their peace. Still, the thoughts of reflecting men naturally and necessarily simmered round the question. De Maillet, a contemporary of Newton, has been brought into notice by Professor Huxley as one who "had a notion of the modifiability of living forms." The late Sir Benjamin Brodie, a man of highly philosophic mind, often drew my attention to the fact that, as early as 1794, Charles Darwin's grandfather was the pioneer of Charles Darwin.[1] In 1801, and in subsequent years, the celebrated Lamarck, who, through the vigorous exposition of his views by the author of the *Vestiges of Creation*, rendered the public mind perfectly familiar with the idea of evolution, endeavoured to show the development of species out of changes of habit and external condition. In 1813 Dr. Wells, the founder of our present theory of Dew, read before the Royal Society a paper in which, to use the words of Mr. Darwin, "he distinctly recognises the principle of natural selection; and this is the first recognition that has been indicated." The thoroughness and skill with which Wells pursued his work, and the obvious independence of his character, rendered him long ago a favourite with me; and it gave me the liveliest pleasure to alight upon this additional testimony to his penetration. Professor Grant, Mr. Patrick Matthew, Von Buch, the author of the *Vestiges*, D'Halloy, and others, by the enunciation of opinions more or less clear and correct, showed that the question had been fermenting long prior to the year 1858, when Mr. Darwin and Mr. Wallace simultaneously, but independently, placed their closely concurrent views before the Linnean Society.[2]

[1] *Zoonomia*, vol. i., pp. 500-510.

[2] In 1855 Mr. Herbert Spencer (*Principles of Psychology*, 2nd edit., vol. i., p. 465) expressed "the belief that life under all its forms has arisen by an unbroken evolution, and through the instrumentality of what are called natural causes." This was my belief also at that time.

These papers were followed in 1859 by the publication of the first edition of the *Origin of Species*. All great things come slowly to the birth. Copernicus, as I informed you, pondered his great work for thirty-three years. Newton for nearly twenty years kept the idea of Gravitation before his mind; for twenty years also he dwelt upon his discovery of Fluxions, and doubtless would have continued to make it the object of his private thought had he not found Leibnitz upon his track. Darwin for two-and-twenty years pondered the problem of the origin of species, and doubtless he would have continued to do so had he not found Wallace upon his track.[1] A concentrated, but full and powerful, epitome of his labours was the consequence. The book was by no means an easy one; and probably not one in every score of those who then attacked it had read its pages through, or were competent to grasp their significance if they had. I do not say this merely to discredit them; for there were in those days some really eminent scientific men, entirely raised above the heat of popular prejudice, and willing to accept any conclusion that science had to offer, provided it was duly backed by fact and argument, who entirely mistook Mr. Darwin's views. In fact, the work needed an expounder, and it found one in Mr. Huxley. I know nothing more admirable in the way of scientific exposition than those early articles of his on the origin of species. He swept the curve of discussion through the really significant points of the subject, enriched his exposition with profound original remarks and reflections, often summing up in a single pithy sentence an argument which a less compact mind would have spread over pages. But there is one impression made by the book itself which no exposition of it, however luminous, can convey; and

[1] The behaviour of Mr. Wallace in relation to this subject has been dignified in the highest degree.

that is the impression of the vast amount of labour, both of observation and of thought, implied in its production. Let us glance at its principles.

It is conceded on all hands that what are called "varieties" are continually produced. The rule is probably without exception. No chick, or child, is in all respects and particulars the counterpart of its brother and sister; and in such differences we have "variety" incipient. No naturalist could tell how far this variation could be carried; but the great mass of them held that never, by any amount of internal or external change, nor by the mixture of both, could the offspring of the same progenitor so far deviate from each other as to constitute different species. The function of the experimental philosopher is to combine the conditions of Nature and to produce her results; and this was the method of Darwin.[1] He made himself acquainted with what could, without any manner of doubt, be done in the way of producing variation. He associated himself with pigeon-fanciers—bought, begged, kept, and observed every breed that he could obtain. Though derived from a common stock, the diversities of these pigeons were such that "a score of them might be chosen which, if shown to an ornithologist, and he were told that they were wild birds, would certainly be ranked by him as well-defined species." The simple principle which guides the pigeon-fancier, as it does the cattle-breeder, is the selection of some variety that strikes his fancy, and the propagation of this variety by inheritance. With his eye still directed to the particular appearance which he wishes to exaggerate, he selects it as it re-appears in successive broods, and thus adds increment to increment until an astonishing amount of divergence from the parent type is effected. The breeder in this case does not produce the *elements* of the variation. He simply observes them, and by selection adds them together until the required result has been obtained. "No man," says Mr. Darwin, "would ever try to make a fantail till he saw a pigeon with a tail developed in some slight degree in an unusual manner, or a pouter until he saw a pigeon with a crop of unusual size." Thus nature gives the hint, man acts upon it, and by the law of inheritance exaggerates the deviation.

Having thus satisfied himself by indubitable facts that the organisation of an animal or of a plant (for precisely the same treatment applies to plants) is to some extent plastic, he passes from variation under domestication to variation under nature. Hitherto we have dealt with the adding together of small changes by the conscious selection of man. Can Nature thus select? Mr. Darwin's answer is, "Assuredly she can." The number of living things produced is far in excess of the number that can be supported; hence at some period or other of their lives there must be a struggle for existence. And what is the infallible result? If one organism were a perfect copy of the other in regard to strength, skill, and agility, external conditions would decide. But this is not the case. Here we have the fact of variety offering itself to nature, as in the former instance it offered itself to man; and those varieties which are least competent to cope with surrounding conditions will infallibly give way to those that are most competent. To use a familiar proverb, the weakest goes to the wall. But the triumphant fraction again breeds to over-production, transmitting the qualities which secured its maintenance, but transmitting them in different degrees. The struggle for food again supervenes, and those to whom the favourable quality has been transmitted in excess will triumph as before.

It is easy to see that we have here the addition of increments favourable to the individual, still more rigorously carried out than in the case of domestication;

[1] The first step only towards experimental demonstration has been taken. Experiments now begun might, a couple of centuries hence, furnish data of incalculable value, which ought to be supplied to the science of the future.

for not only are unfavourable specimens not selected by nature, but they are destroyed. This is what Mr. Darwin calls "Natural Selection," which acts by the preservation and accumulation of small inherited modifications, each profitable to the preserved being. With this idea he interpenetrates and leavens the vast store of facts that he and others have collected. We cannot, without shutting our eyes through fear or prejudice, fail to see that Darwin is here dealing, not with imaginary, but with true causes; nor can we fail to discern what vast modifications may be produced by natural selection in periods sufficiently long. Each individual increment may resemble what mathematicians call a "differential" (a quantity indefinitely small); but definite and great changes may obviously be produced by the integration of these infinitesimal quantities, through practically infinite time.

If Darwin, like Bruno, rejects the notion of creative power, acting after human fashion, it certainly is not because he is unacquainted with the numberless exquisite adaptations on which this notion of a supernatural Artificer has been founded. His book is a repository of the most startling facts of this description. Take the marvellous observation which he cites from Dr. Krüger, where a bucket with an aperture serving as a spout is formed in an orchid. Bees visit the flower; in eager search of material for their combs they push each other into the bucket, the drenched ones escaping from their involuntary bath by the spout. Here they rub their backs against the viscid stigma of the flower and obtain glue; then against the pollen-masses, which are thus stuck to the back of the bee and carried away. "When the bee, so provided, flies to another flower, or to the same flower a second time, and is pushed by its comrades into the bucket, and then crawls out by the passage, the pollen-mass upon its back necessarily comes first into contact with the viscid stigma," which takes up the pollen; and this is how that orchid is fertilised. Or take this other case of the *Catasetum*. "Bees visit these flowers in order to gnaw the labellum; in doing this they inevitably touch a long, tapering, sensitive projection. This, when touched, transmits a sensation or vibration to a certain membrane, which is instantly ruptured, setting free a spring, by which the pollen-mass is shot forth like an arrow in the right direction, and adheres by its viscid extremity to the back of the bee." In this way the fertilising pollen is spread abroad.

It is the mind thus stored with the choicest materials of the teleologist that rejects teleology, seeking to refer these wonders to natural causes. They illustrate, according to him, the method of nature, not the "technic" of a manlike Artificer. The beauty of flowers is due to natural selection. Those that distinguish themselves by vividly contrasting colours from the surrounding green leaves are most readily seen, most frequently visited by insects, most often fertilised, and hence most favoured by natural selection. Coloured berries also readily attract the attention of birds and beasts, which feed upon them, spread their manured seeds abroad, thus giving trees and shrubs possessing such berries a greater chance in the struggle for existence.

With profound analytic and synthetic skill, Mr. Darwin investigates the cell-making instinct of the hive-bee. His method of dealing with it is representative. He falls back from the more perfectly to the less perfectly developed instinct—from the hive-bee to the humble-bee, which uses its own cocoon as a comb, and to classes of bees of intermediate skill endeavouring to show how the passage might be gradually made from the lowest to the highest. The saving of wax is the most important point in the economy of bees. Twelve to fifteen pounds of dry sugar are said to be needed for the secretion of a single pound of wax. The quantities of nectar necessary for the wax must therefore be vast, and every improvement of constructive instinct which results in the saving

of wax is a direct profit to the insect's life. The time that would otherwise be devoted to the making of wax is devoted to the gathering and storing of honey for winter food. Mr. Darwin passes from the humble-bee, with its rude cells, through the Melipona, with its more artistic cells, to the hive-bee with its astonishing architecture. The bees place themselves at equal distances apart upon the wax, sweep and excavate equal spheres round the selected points. The spheres intersect, and the planes of intersection are built up with thin laminæ. Hexagonal cells are thus formed. This mode of treating such questions is, as I have said, representative. The expositor habitually retires from the more perfect and complex, to the less perfect and simple, and carries you with him through stages of *perfecting*—adds increment to increment of infinitesimal change, and in this way gradually breaks down your reluctance to admit that the exquisite climax of the whole could be a result of natural selection.

Mr. Darwin shirks no difficulty; and, saturated as the subject was with his own thought, he must have known, better than his critics, the weakness as well as the strength of his theory. This of course would be of little avail were his object a temporary dialectic victory, instead of the establishment of a truth which he means to be everlasting. But he takes no pains to disguise the weakness he has discerned; nay, he takes every pains to bring it into the strongest light. His vast resources enable him to cope with objections started by himself and others, so as to leave the final impression upon the reader's mind that, if they be not completely answered, they certainly are not fatal. Their negative force being thus destroyed, you are free to be influenced by the vast positive mass of evidence he is able to bring before you. This largeness of knowledge and readiness of resource render Mr. Darwin the most terrible of antagonists. Accomplished naturalists have levelled heavy and sustained criticisms against him—not always with the view of fairly weighing his theory, but with the express intention of exposing its weak points only. This does not irritate him. He treats every objection with a soberness and thoroughness which even Bishop Butler might be proud to imitate, surrounding each fact with its appropriate detail, placing it in its proper relations, and usually giving it a significance which, as long as it was kept isolated, failed to appear. This is done without a trace of ill-temper. He moves over the subject with the passionless strength of a glacier; and the grinding of the rocks is not always without a counterpart in the logical pulverisation of the objector. But though in handling this mighty theme all passion has been stilled, there is an emotion of the intellect, incident to the discernment of new truth, which often colours and warms the pages of Mr. Darwin. His success has been great; and this implies not only the solidity of his work, but the preparedness of the public mind for such a revelation. On this head a remark of Agassiz impressed me more than anything else. Sprung from a race of theologians, this celebrated man combated to the last the theory of natural selection. One of the many times I had the pleasure of meeting him in the United States was at Mr. Winthrop's beautiful residence at Brookline, near Boston. Rising from luncheon, we all halted as if by common consent in front of a window, and continued there a discussion which had been started at table. The maple was in its autumn glory, and the exquisite beauty of the scene outside seemed, in my case, to interpenetrate without disturbance the intellectual action. Earnestly, almost sadly, Agassiz turned, and said to the gentlemen standing round: "I confess that I was not prepared to see this theory received as it has been by the best intellects of our time. Its success is greater than I could have thought possible."

§ 7.

In our day grand generalisations have been reached. The theory of the origin of species is but one of them. Another, of still wider grasp and more radical significance, is the doctrine of the Conservation of Energy, the ultimate philosophical issues of which are as yet but dimly seen—that doctrine which "binds nature fast in fate," to an extent not hitherto recognised, exacting from every antecedent its equivalent consequent, from every consequent its equivalent antecedent, and bringing vital as well as physical phenomena under the dominion of that law of causal connection which, so far as the human understanding has yet pierced, asserts itself everywhere in nature. Long in advance of all definite experiment upon the subject, the constancy and indestructibility of matter had been affirmed; and all subsequent experience justified the affirmation. Mayer extended the attribute of indestructibility to energy, applying it in the first instance to inorganic,[1] and afterwards with profound insight to organic nature. The vegetable world, though drawing all its nutriment from invisible sources, was proved incompetent to generate anew either matter or force. Its matter is for the most part transmuted gas; its force transformed solar force. The animal world was proved to be equally uncreative, all its motive energies being referred to the combustion of its food. The activity of each animal, as a whole, was proved to be the transferred activity of its molecules. The muscles were shown to be stores of mechanical energy, potential until unlocked by the nerves, and then resulting in muscular contractions. The speed at which messages fly to and fro along the nerves was determined by Helmholtz, and found to be, not, as had been previously supposed, equal to that of light or electricity, but less than the speed of sound—less even than that of an eagle.

This was the work of the physicist: then came the conquests of the comparative anatomist and physiologist, revealing the structure of every animal and the function of every organ in the whole biological series, from the lowest zoophyte up to man. The nervous system had been made the object of profound and continued study, the wonderful, and, at bottom, entirely mysterious controlling power which it exercises over the whole organism, physical and mental, being recognised more and more. Thought could not be kept back from a subject so profoundly suggestive. Besides the physical life dealt with by Mr. Darwin, there is a psychical life presenting similar gradations, and asking equally for a solution. How are the different grades and orders of Mind to be accounted for? What is the principle of growth of that mysterious power which on our planet culminates in Reason? These are questions which, though not thrusting themselves so forcibly upon the attention of the general public, had not only occupied many reflecting minds, but had been formally broached by one of them before the *Origin of Species* appeared.

With the mass of materials furnished by the physicist and physiologist in his hands, Mr. Herbert Spencer, twenty years ago, sought to graft upon this basis a system of psychology; and two years ago a second and greatly amplified edition of his work appeared. Those who have occupied themselves with the beautiful experiments of Plateau will remember that when two spherules of olive-oil, suspended in a mixture of alcohol and water of the same density as the oil, are brought together, they do not immediately unite. Something like a pellicle appears to be formed around the drops, the rupture of which is immediately followed by the coalescence of the globules into one. There are organisms whose vital actions are almost as purely physical as the coalescence of such drops

[1] Dr. Berthold has shown that Leibnitz had sound views regarding the conservation of energy in inorganic nature.

of oil. They come into contact and fuse themselves thus together. From such organisms to others a shade higher, from these to others a shade higher still, and on through an ever-ascending series, Mr. Spencer conducts his argument. There are two obvious factors to be here taken into account—the creature and the medium in which it lives, or, as it is often expressed, the organism and its environment. Mr. Spencer's fundamental principle is, that between these two factors there is incessant interaction. The organism is played upon by the environment, and is modified to meet the requirements of the environment. Life he defines to be "a continuous adjustment of internal relations to external relations."

In the lowest organisms we have a kind of tactual sense diffused over the entire body; then, through impressions from without and their corresponding adjustments, special portions of the surface become more responsive to stimuli than others. The senses are nascent, the basis of all of them being that simple tactual sense which the sage Democritus recognised 2,300 years ago as their common progenitor. The action of light, in the first instance, appears to be a mere disturbance of the chemical processes in the animal organism, similar to that which occurs in the leaves of plants. By degrees the action becomes localised in a few pigment-cells, more sensitive to light than the surrounding tissue. The eye is incipient. At first it is merely capable of revealing differences of light and shade produced by bodies close at hand. Followed, as the interception of the light commonly is, by the contact of the closely adjacent opaque body, sight in this condition becomes a kind of "anticipatory touch." The adjustment continues; a slight bulging out of the epidermis over the pigment-granules supervenes. A lens is incipient, and, through the operation of infinite adjustments, at length reaches the perfection that it displays in the hawk and eagle. So of the other senses; they are special differentiations of a tissue which was originally vaguely sensitive all over.

With the development of the senses, the adjustments between the organism and its environment gradually extend in *space*, a multiplication of experiences and a corresponding modification of conduct being the result. The adjustments also extend in *time*, covering continually greater intervals. Along with this extension in space and time the adjustments also increase in speciality and complexity, passing through the various grades of brute life, and prolonging themselves into the domain of reason. Very striking are Mr. Spencer's remarks regarding the influence of the sense of touch upon the development of intelligence. This is, so to say, the mother-tongue of all the senses, into which they must be translated to be of service to the organism. Hence its importance. The parrot is the most intelligent of birds, and its tactual power is also greatest. From this sense it gets knowledge, unattainable by birds which cannot employ their feet as hands. The elephant is the most sagacious of quadrupeds—its tactual range and skill, and the consequent multiplication of experiences, which it owes to its wonderfully adaptable trunk, being the basis of its sagacity. Feline animals, for a similar cause, are more sagacious than hoofed animals—atonement being to some extent made in the case of the horse by the possession of sensitive prehensile lips. In the *Primates* the evolution of intellect and the evolution of tactual appendages go hand in hand. In the most intelligent anthropoid apes we find the tactual range and delicacy greatly augmented, new avenues of knowledge being thus opened to the animal. Man crowns the edifice here, not only in virtue of his own manipulatory power, but through the enormous extension of his range of experience, by the invention of instruments of precision, which serve as supplemental senses and supplemental limbs. The reciprocal action of these is finely described and illustrated. That chastened intellectual emotion, to which

I have referred in connection with Mr. Darwin, is not absent in Mr. Spencer. His illustrations possess at times exceeding vividness and force; and from his style on such occasions it is to be inferred that the ganglia of this Apostle of the Understanding are sometimes the seat of a nascent poetic thrill.

It is a fact of supreme importance that actions, the performance of which at first requires even painful effort and deliberation, may, by habit, be rendered automatic. Witness the slow learning of its letters by a child, and the subsequent facility of reading in a man, when each group of letters which forms a word is instantly, and without effort, fused to a single perception. Instance the billiard-player, whose muscles of hand and eye, when he reaches the perfection of his art, are unconsciously co-ordinated. Instance the musician, who, by practice, is enabled to fuse a multitude of arrangements, auditory, tactual, and muscular, into a process of automatic manipulation. Combining such facts with the doctrine of hereditary transmission, we reach a theory of Instinct. A chick, after coming out of the egg, balances itself correctly, runs about, picks up food, thus showing that it possesses a power of directing its movements to definite ends. How did the chick learn this very complex co-ordination of eyes, muscles, and beak? It has not been individually taught; its personal experience is *nil*; but it has the benefit of ancestral experience. In its inherited organisation are registered the powers which it displays at birth. So also as regards the instinct of the hive-bee, already referred to. The distance at which the insects stand apart when they sweep their hemispheres and build their cells is "organically remembered." Man also carries with him the physical texture of his ancestry, as well as the inherited intellect bound up with it. The defects of intelligence during infancy and youth are probably less due to a lack of individual experience than to the fact that in early life the cerebral organisation is still incomplete. The period necessary for completion varies with the race and with the individual. As a round shot outstrips the rifled bolt on quitting the muzzle of the gun, so the lower race, in childhood, may outstrip the higher. But the higher eventually overtakes the lower, and surpasses it in range. As regards individuals, we do not always find the precocity of youth prolonged to mental power in maturity; while the dulness of boyhood is sometimes strikingly contrasted with the intellectual energy of after years. Newton, when a boy, was weakly, and he showed no particular aptitude at school; but in his eighteenth year he went to Cambridge, and soon afterwards astonished his teachers by his power of dealing with geometrical problems. During his quiet youth his brain was slowly preparing itself to be the organ of those energies which he subsequently displayed.

By myriad blows (to use a Lucretian phrase) the image and superscription of the external world are stamped as states of consciousness upon the organism, the depth of the impression depending on the number of the blows. When two or more phenomena occur in the environment invariably together, they are stamped to the same depth or to the same relief, and indissolubly connected. And here we come to the threshold of a great question. Seeing that he could in no way rid himself of the consciousness of Space and Time, Kant assumed them to be necessary "forms of intuition," the moulds and shapes into which our intuitions are thrown belonging to ourselves, and without objective existence. With unexpected power and success, Mr. Spencer brings the hereditary experience theory, as he holds it, to bear upon this question. "If there exist certain external relations which are experienced by all organisms at all instants of their waking lives—relations which are absolutely constant and universal—there will be established answering internal relations, that are absolutely constant and universal. Such relations we have in those of Space and Time. As the substratum of all other

relations of the Non-Ego, they must be responded to by conceptions that are the substrata of all other relations in the Ego. Being the constant and infinitely repeated elements of thought, they must become the automatic elements of thought—the elements of thought which it is impossible to get rid of—the "forms of intuition."

Throughout this application and extension of Hartley's and Mill's "Law of Inseparable Association," Mr. Spencer stands upon his own ground, invoking, instead of the experiences of the individual, the registered experiences of the race. His overthrow of the restriction of experience to the individual is, I think, complete. That restriction ignores the power of organising experience, furnished at the outset to each individual; it ignores the different degrees of this power possessed by different races, and by different individuals of the same race. Were there not in the human brain a potency antecedent to all experience, a dog or a cat ought to be as capable of education as a man. These predetermined internal relations are independent of the experiences of the individual. The human brain is the "organised register of infinitely numerous experiences received during the evolution of life, or rather during the evolution of that series of organisms through which the human organism has been reached. The effects of the most uniform and frequent of these experiences have been successively bequeathed, principal and interest, and have slowly mounted to that high intelligence which lies latent in the brain of the infant. Thus it happens that the European inherits from twenty to thirty cubic inches more of brain than the Papuan. Thus it happens that faculties, as of music, which scarcely exist in some inferior races, become congenital in superior ones. Thus it happens that out of savages unable to count up to the number of their fingers, and speaking a language containing only nouns and verbs, arise at length our Newtons and Shakespeares."

§ 8.

At the outset of this Address it was stated that physical theories which lie beyond experience are derived by a process of abstraction from experience. It is instructive to note from this point of view the successive introduction of new conceptions. The idea of the attraction of gravitation was preceded by the observation of the attraction of iron by a magnet, and of light bodies by rubbed amber. The polarity of magnetism and electricity also appealed to the senses. It thus became the substratum of the conception that atoms and molecules are endowed with attractive and repellent poles, by the play of which definite forms of crystalline architecture are produced. Thus molecular force becomes *structural*.[1] It required no great boldness of thought to extend its play into organic nature, and to recognise in molecular force the agency by which both plants and animals are built up. In this way, out of experience arise conceptions which are wholly ultra-experiential. None of the atomists of antiquity had any notion of this play of molecular polar force, but they had experience of gravity, as manifested by falling bodies. Abstracting from this, they permitted their atoms to fall eternally through empty space. Democritus assumed that the larger atoms moved more rapidly than the smaller ones, which they therefore could overtake, and with which they could combine. Epicurus, holding that empty space could offer no resistance to motion, ascribed to all the atoms the same velocity; but he seems to have overlooked the consequence that under such circumstances the atoms could never combine. Lucretius cut the knot by quitting the domain of physics altogether, and causing the atoms to move together by a kind of volition.

Was the instinct utterly at fault which

[1] See *Fragments of Science*, vol. ii., article on "Matter and Force"; or *Lectures on Light*, No. III.

caused Lucretius thus to swerve from his own principles? Diminishing gradually the number of progenitors, Mr. Darwin comes at length to one "primordial form"; but he does not say, so far as I remember, how he supposes this form to have been introduced. He quotes with satisfaction the words of a celebrated author and divine who had "gradually learnt to see that it was just as noble a conception of the Deity to believe He created a few original forms, capable of self-development into other and needful forms, as to believe He required a fresh act of creation to supply the voids caused by the action of His laws." What Mr. Darwin thinks of this view of the introduction of life I do not know. But the anthropomorphism, which it seemed his object to set aside, is as firmly associated with the creation of a few forms as with the creation of a multitude. We need clearness and thoroughness here. Two courses, and two only, are possible. Either let us open our doors freely to the conception of creative acts, or, abandoning them, let us radically change our notions of matter. If we look at matter as pictured by Democritus, and as defined for generations in our scientific text-books, the notion of conscious life coming out of it cannot be formed by the mind. The argument placed in the mouth of Bishop Butler suffices, in my opinion, to crush all such materialism as this. Those, however, who framed these definitions of matter were but partial students. They were not biologists, but mathematicians, whose labours referred only to such accidents and properties of matter as could be expressed in their formulæ. Their science was mechanical science, not the science of life. With matter in its wholeness they never dealt; and, denuded by their imperfect definitions, "the gentle mother of all" became the object of her children's dread. Let us reverently, but honestly, look the question in the face. Divorced from matter, where is life? Whatever our *faith* may say, our *knowledge* shows them to be indissolubly joined. Every meal we eat, every cup we drink, illustrates the mysterious control of mind by matter.

On tracing the line of life backwards, we see it approaching more and more to what we call the purely physical condition. We come at length to those organisms which I have compared to drops of oil suspended in a mixture of alcohol and water. We reach the *protogenes* of Haeckel, in which we have "a type distinguishable from a fragment of albumen only by its finely granular character." Can we pause here? We break a magnet, and find two poles in each of its fragments. We continue the process of breaking; but, however small the parts, each carries with it, though enfeebled, the polarity of the whole. And when we can break no longer, we prolong the intellectual vision to the polar molecules. Are we not urged to do *something* similar in the case of life? Is there not a temptation to close to some extent with Lucretius, when he affirms that "Nature is seen to do all things spontaneously of herself without the meddling of the gods"? or with Bruno, when he declares that matter is not "that mere empty *capacity* which philosophers have pictured her to be, but the universal mother who brings forth all things as the fruit of her own womb"? Believing, as I do, in the continuity of nature, I cannot stop abruptly where our microscopes cease to be of use. Here the vision of the mind authoritatively supplements the vision of the eye. By a necessity engendered and justified by science I cross the boundary of the experimental evidence, and discern in that matter which we, in our ignorance of its latent powers, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of all terrestrial life.

If you ask me whether there exists the least evidence to prove that any form of life can be developed out of matter, without demonstrable antecedent life, my reply is that evidence considered

perfectly conclusive by many has been adduced; and that were some of us who have pondered this question to follow a very common example and accept testimony because it falls in with our belief, we also should eagerly close with the evidence referred to. But there is in the true man of science a desire stronger than the wish to have his beliefs upheld —namely, the desire to have them true. And this stronger wish causes him to reject the most plausible support, if he has reason to suspect that it is vitiated by error. Those to whom I refer as having studied this question, believing the evidence offered in favour of "spontaneous generation" to be thus vitiated, cannot accept it. They know full well that the chemist now prepares from inorganic matter a vast array of substances, which were some time ago regarded as the sole products of vitality. They are intimately acquainted with the structural power of matter, as evidenced in the phenomena of crystallisation. They can justify scientifically their *belief* in its potency, under the proper conditions, to produce organisms. But, in reply to your question, they will frankly admit their inability to point to any satisfactory experimental proof that life can be developed, save from demonstrable antecedent life. As already indicated, they draw the line from the highest organisms through lower ones down to the lowest; and it is the prolongation of this line by the intellect, beyond the range of the senses, that leads them to the conclusion which Bruno so boldly enunciated.[1]

The "materialism" here professed may be vastly different from what you suppose, and I therefore crave your gracious patience to the end. "The question of an external world," says J. S. Mill, "is the great battle-ground of metaphysics."[2] Mr. Mill himself reduces external phenomena to "possibilities of sensation." Kant, as we have seen, made time and space "forms" of our own intuitions. Fichte, having first by the inexorable logic of his understanding proved himself to be a mere link in that chain of eternal causation which holds so rigidly in nature, violently broke the chain by making nature, and all that it inherits, an apparition of the mind.[1] And it is by no means easy to combat such notions. For when I say "I see you," and that there is not the least doubt about it, the obvious reply is, that what I am really conscious of is an affection of my own retina. And if I urge that my sight can be checked by touching you, the retort would be that I am equally transgressing the limits of fact; for what I am really conscious of is, not that you are there, but that the nerves of my hand have undergone a change. All we hear, and see, and touch, and taste, and smell are, it would be urged, mere variations of our own condition, beyond which, even to the extent of a hair's breadth, we cannot go. That anything answering to our impressions exists outside of ourselves is not a *fact*, but an *inference*, to which all validity would be denied by an idealist like Berkeley, or by a sceptic like Hume. Mr. Spencer takes another line. With him, as with the uneducated man, there is no doubt or question as to the existence of an external world. But he differs from the uneducated, who think that the world really *is* what consciousness represents it to be. Our states of consciousness are mere *symbols* of an outside entity which produces them and determines the order of their succession, but the real nature of which we can never know.[2] In fact, the whole process of evolution is the manifestation of a power absolutely inscrutable to the

[1] Bruno was a "Pantheist," not an "Atheist" or a "Materialist."

[2] *Examination of Hamilton*, p. 154.

[1] *Bestimmung des Menschen.*

[2] In a paper, at once popular and profound, entitled "Recent Progress in the Theory of Vision," contained in the volume of lectures by Helmholtz, published by Longmans, this symbolism of our states of consciousness is also dwelt upon. The impressions of sense are the mere *signs* of external things. In this paper Helmholtz contends strongly against the view that the consciousness of space is inborn; and

intellect of man. As little in our day as in the days of Job can man by searching find this Power out. Considered fundamentally, then, it is by the operation of an insoluble mystery that life on earth is evolved, species differentiated, and mind unfolded, from their prepotent elements in the immeasurable past.

The strength of the doctrine of Evolution consists, not in an experimental demonstration (for the subject is hardly accessible to this mode of proof), but in its general harmony with scientific thought. From contrast, moreover, it derives enormous relative cogency. On the one side we have a theory (if it could with any propriety be so called) derived, as were the theories referred to at the beginning of this Address, not from the study of nature, but from the observation of men—a theory which converts the Power whose garment is seen in the visible universe into an Artificer, fashioned after the human model, and acting by broken efforts as man is seen to act. On the other side we have the conception that all we see around us, and all we feel within us—the phenomena of physical nature as well as those of the human mind—have their unsearchable roots in a cosmical life, if I dare apply the term, an infinitesimal span of which is offered to the investigation of man. And even this span is only knowable in part. We can trace the development of a nervous system, and correlate with it the parallel phenomena of sensation and thought. We see with undoubting certainty that they go hand in hand. But we try to soar in a vacuum the moment we seek to comprehend the connection between them. An Archimedean fulcrum is here required which the human mind cannot command; and the effort to solve the problem—to borrow a comparison from an illustrious friend of mine—is like that of a man trying to lift himself by his own waistband. All that has been said in this discourse is to be taken in connection with this fundamental truth. When "nascent senses" are spoken of, when "the differentiation of a tissue at first vaguely sensitive all over" is spoken of, and when these possessions and processes are associated with "the modification of an organism by its environment," the same parallelism, without contact, or even approach to contact, is implied. Man the *object* is separated by an impassable gulf from man the *subject*. There is no motor energy in the human intellect to carry it, without logical rupture, from the one to the other.

he evidently doubts the power of the chick to pick up grains of corn without preliminary lessons. On this point, he says, further experiments are needed. Such experiments have been since made by Mr. Spalding, and they seem to prove conclusively that the chick does not need a single moment's tuition to enable it to stand, run, govern the muscles of its eyes, and peck. Helmholtz, however, is contending against the notion of pre-established harmony; and I am not aware of his views as to the organisation of experiences of race or breed.

§ 9.

The doctrine of Evolution derives man, in his totality, from the interaction of organism and environment through countless ages past. The Human Understanding, for example—that faculty which Mr. Spencer has turned so skilfully round upon its own antecedents—is itself a result of the play between organism and environment through cosmic ranges of time. Never, surely, did prescription plead so irresistible a claim. But then it comes to pass that, over and above his understanding, there are many other things appertaining to man whose prescriptive rights are quite as strong as those of the understanding itself. It is a result, for example, of the play of organism and environment that sugar is sweet, and that aloes are bitter; that the smell of henbane differs from the perfume of a rose. Such facts of consciousness (for which, by the way, no adequate reason has ever been rendered) are quite as old as the understanding; and many other things can boast an equally ancient origin. Mr. Spencer at one place refers

to that most powerful of passions—the amatory passion—as one which, when it first occurs, is antecedent to all relative experience whatever; and we may press its claim as being at least as ancient, and as valid, as that of the understanding itself. Then there are such things woven into the texture of man as the feeling of Awe, Reverence, Wonder—and not alone the sexual love just referred to, but the love of the beautiful, physical, and moral, in Nature, Poetry, and Art. There is also that deep-set feeling, which, since the earliest dawn of history, and probably for ages prior to all history, incorporated itself in the religions of the world. You, who have escaped from these religions into the high-and-dry light of the intellect, may deride them; but in so doing you deride accidents of form merely, and fail to touch the immovable basis of the religious sentiment in the nature of man. To yield this sentiment reasonable satisfaction is the problem of problems at the present hour. And grotesque in relation to scientific culture as many of the religions of the world have been and are—dangerous, nay, destructive, to the dearest privileges of freemen as some of them undoubtedly have been, and would, if they could, be again—it will be wise to recognise them as the forms of a force, mischievous if permitted to intrude on the region of objective *knowledge*, over which it holds no command, but capable of adding, in the region of *poetry* and *emotion*, inward completeness and dignity to man.

Feeling, I say again, dates from as old an origin and as high a source as intelligence, and it equally demands its range of play. The wise teacher of humanity will recognise the necessity of meeting this demand, rather than of resisting it on account of errors and absurdities of form. What we should resist, at all hazards, is the attempt made in the past, and now repeated, to found upon this elemental bias of man's nature a system which should exercise despotic sway over his intellect. I have no fear of such a consummation. Science has already to some extent leavened the world; it will leaven it more and more. I should look upon the mild light of science breaking in upon the minds of the youth of Ireland, and strengthening gradually to the perfect day, as a surer check to any intellectual or spiritual tyranny which may threaten this island than the laws of princes or the swords of emperors. We fought and won our battle even in the Middle Ages: should we doubt the issue of another conflict with our broken foe?

The impregnable position of science may be described in a few words. We claim, and we shall wrest from theology, the entire domain of cosmological theory. All schemes and systems which thus infringe upon the domain of science must, in so far as they do this, submit to its control, and relinquish all thought of controlling it. Acting otherwise proved always disastrous in the past, and it is simply fatuous to-day. Every system which would escape the fate of an organism too rigid to adjust itself to its environment must be plastic to the extent that the growth of knowledge demands. When this truth has been thoroughly taken in, rigidity will be relaxed, exclusiveness diminished, things now deemed essential will be dropped, and elements now rejected will be assimilated. The lifting of the life is the essential point, and as long as dogmatism, fanaticism, and intolerance are kept out, various modes of leverage may be employed to raise life to a higher level.

Science itself not unfrequently derives motive power from an ultra-scientific source. Some of its greatest discoveries have been made under the stimulus of a non-scientific ideal. This was the case among the ancients, and it has been so among ourselves. Mayer, Joule, and Colding, whose names are associated with the greatest of modern generalisations, were thus influenced. With his usual insight, Lange at one place remarks that "it is not always the objectively correct and intelligible that helps man most, or leads most quickly to the fullest and truest knowledge. As the

sliding body upon the brachystochrone reaches its end sooner than by the straighter road of the inclined plane, so, through the swing of the ideal, we often arrive at the naked truth more rapidly than by the processes of the understanding." Whewell speaks of enthusiasm of temper as a hindrance to science; but he means the enthusiasm of weak heads. There is a strong and resolute enthusiasm in which science finds an ally; and it is to the lowering of this fire, rather than to the diminution of intellectual insight, that the lessening productiveness of men of science, in their mature years, is to be ascribed. Mr. Buckle sought to detach intellectual achievement from moral force. He gravely erred; for without moral force to whip it into action the achievement of the intellect would be poor indeed.

It has been said by its opponents that science divorces itself from literature; but the statement, like so many others, arises from lack of knowledge. A glance at the less technical writings of its leaders —of its Helmholtz, its Huxley, and its Du Bois-Reymond—would show what breadth of literary culture they command. Where among modern writers can you find their superiors in clearness and vigour of literary style? Science desires not isolation, but freely combines with every effort towards the bettering of man's estate. Single-handed, and supported, not by outward sympathy, but by inward force, it has built at least one great wing of the many-mansioned home which man in his totality demands. And if rough walls and protruding rafter-ends indicate that on one side the edifice is still incomplete, it is only by wise combination of the parts required, with those already irrevocably built, that we can hope for completeness. There is no necessary incongruity between what has been accomplished and what remains to be done. The moral glow of Socrates, which we all feel by ignition, has in it nothing incompatible with the physics of Anaxagoras which he so much scorned, but which he would hardly scorn to-day. And here I am reminded of one among us, hoary, but still strong, whose prophet-voice some thirty years ago, far more than any other of this age, unlocked whatever of life and nobleness lay latent in its most gifted minds—one fit to stand beside Socrates or the Maccabean Eleazar, and to dare and suffer all that they suffered and dared—fit, as he once said of Fichte, "to have been the teacher of the Stoa, and to have discoursed of Beauty and Virtue in the groves of Academe." With a capacity to grasp physical principles which his friend Goethe did not possess, and which even total lack of exercise has not been able to reduce to atrophy, it is the world's loss that he, in the vigour of his years, did not open his mind and sympathies to science, and make its conclusions a portion of his message to mankind. Marvellously endowed as he was—equally equipped on the side of the Heart and of the Understanding—he might have done much towards teaching us how to reconcile the claims of both, and to enable them in coming times to dwell together, in unity of spirit and in the bond of peace.

And now the end is come. With more time, or greater strength and knowledge, what has been here said might have been better said, while worthy matters, here omitted, might have received fit expression. But there would have been no material deviation from the views set forth. As regards myself, they are not the growth of a day; and as regards you, I thought you ought to know the environment which, with or without your consent, is rapidly surrounding you, and in relation to which some adjustment on your part may be necessary. A hint of Hamlet's, however, teaches us how the troubles of common life may be ended; and it is perfectly possible for you and me to purchase intellectual peace at the price of intellectual death. The world is not without refuges of this description; nor is it wanting in persons who seek their

shelter, and try to persuade others to do the same. The unstable and the weak have yielded and will yield to this persuasion, and they to whom repose is sweeter than the truth. But I would exhort you to refuse the offered shelter, and to scorn the base repose—to accept, if the choice be forced upon you, commotion before stagnation, the breezy leap of the torrent before the fœtid stillness of the swamp. In the course of this Address I have touched on debatable questions, and led you over what will be deemed dangerous ground—and this partly with the view of telling you that, as regards these questions, science claims unrestricted right of search. It is not to the point to say that the views of Lucretius and Bruno, of Darwin and Spencer, may be wrong. Here I should agree with you, deeming it indeed certain that these views will undergo modification. But the point is that, whether right or wrong, we claim the right to discuss them. For science, however, no exclusive claim is here made; you are not urged to erect it into an idol. The inexorable advance of man's understanding in the path of knowledge, and those unquenchable claims of his moral and emotional nature which the understanding can never satisfy, are here equally set forth. The world embraces not only a Newton, but a Shakespeare—not only a Boyle, but a Raphael—not only a Kant, but a Beethoven—not only a Darwin, but a Carlyle. Not in each of these, but in all, is human nature whole. They are not opposed, but supplementary—not mutually exclusive, but reconcilable. And if, unsatisfied with them all, the human mind, with the yearning of a pilgrim for his distant home, will still turn to the Mystery from which it has emerged, seeking so to fashion it as to give unity to thought and faith; so long as this is done, not only without intolerance or bigotry of any kind, but with the enlightened recognition that ultimate fixity of conception is here unattainable, and that each succeeding age must be held free to fashion the mystery in accordance with its own needs—then, casting aside all the restrictions of Materialism, I would affirm this to be a field for the noblest exercise of what, in contrast with the *knowing* faculties, may be called the *creative* faculties of man. Here, however, I touch a theme too great for me to handle, but which will assuredly be handled by the loftiest minds, when you and I, like streaks of morning cloud, shall have melted into the infinite azure of the past.

APOLOGY FOR THE BELFAST ADDRESS[1]

1874

THE world has been frequently informed of late that I have raised up against myself a host of enemies; and considering, with few exceptions, the deliverances of the Press, and more particularly of the religious Press, I am forced to admit that the statement is only too true. I derive some comfort, nevertheless, from the reflection of Diogenes, transmitted to us by Plutarch, that "he who would be saved must have good friends or violent enemies; and that he is best off who possesses both." This "best" condition, I have reason to believe, is mine.

Reflecting on the fraction I have read of recent remonstrances, appeals,

[1] The word "Apology" is here used in its original sense, as signifying "Vindication" or "Defence"; no retractation is implied.—ED.

menaces, and judgments—covering not only the world that now is, but that which is to come—I have noticed with mournful interest how trivially men seem to be influenced by what they call their religion, and how potently by that "nature" which it is the alleged province of religion to eradicate or subdue. From fair and manly argument, from the tenderest and holiest sympathy on the part of those who desire my eternal good, I pass by many gradations, through deliberate unfairness, to a spirit of bitterness, which desires with a fervour inexpressible in words my eternal ill. Now, were religion the potent factor, we might expect a homogeneous utterance from those professing a common creed, while, if human nature be the really potent factor, we may expect utterances as heterogeneous as the characters of men. As a matter of fact, we have the latter; suggesting to my mind that the common religion, professed and defended by these different people, is merely the accidental conduit through which they pour their own tempers, lofty or low, courteous or vulgar, mild or ferocious, as the case may be. Pure abuse, however, as serving no good end, I have, wherever possible, deliberately avoided reading, wishing, indeed, to keep, not only hatred, malice, and uncharitableness, but even every trace of irritation, far away from my side of a discussion which demands not only good-temper, but largeness, clearness, and many-sidedness of mind, if it is to guide us to even provisional solutions.

It has been stated, with many variations of note and comment, that in the Address as subsequently published by Messrs. Longman I have retracted opinions uttered at Belfast. A Roman Catholic writer is specially strong upon this point. Startled by the deep chorus of dissent which my "dazzling fallacies" have evoked, I am now trying to retreat. This he will by no means tolerate. "It is too late now to seek to hide from the eyes of mankind one foul blot, one ghastly deformity. Professor Tyndall has himself told us how and where this Address of his was composed. It was written among the glaciers and the solitudes of the Swiss mountains. It was no hasty, hurried, crude production; its every sentence bore marks of thought and care."

My critic intends to be severe: he is simply just. In the "solitudes" to which he refers I worked with deliberation, endeavouring even to purify my intellect by disciplines similar to those enjoined by his own Church for the sanctification of the soul. I tried, moreover, in my ponderings to realise not only the lawful, but the expedient; and to permit no fear to act upon my mind, save that of uttering a single word on which I could not take my stand, either in this or in any other world.

Still my time was so brief, the difficulties arising from my isolated position were so numerous, and my thought and expression so slow, that, in a literary point of view, I halted, not only behind the ideal, but behind the possible. Hence, after the delivery of the Address, I went over it with the desire, not to revoke its principles, but to improve it verbally, and above all to remove any word which might give colour to the notion of "crudeness, hurry, or haste."

In connection with the charge of Atheism my critic refers to the Preface to the second issue of the Belfast Address. "Christian men," I there say, "are proved by their writings to have their hours of weakness and of doubt, as well as their hours of strength and of conviction; and men like myself share, in their own way, these variations of mood and tense. Were the religious moods of many of my assailants the only alternative ones, I do not know how strong the claims of the doctrine of 'Material Atheism' upon my allegiance might be. Probably they would be very strong. But, as it is, I have noticed during years of self-observation that it is not in hours of clearness and vigour that this doctrine commends itself to my mind; that in the presence of stronger

and healthier thought it ever dissolves and disappears, as offering no solution of the mystery in which we dwell, and of which we form a part."

With reference to this honest and reasonable utterance my censor exclaims: "This is a most remarkable passage. Much as we dislike seasoning polemics with strong words, we assert that this apology only tends to affix with links of steel, to the name of Professor Tyndall, the dread imputation against which he struggles."

Here we have a very fair example of subjective religious vigour. But my quarrel with such exhibitions is that they do not always represent objective fact. No atheistic reasoning can, I hold, dislodge religion from the human heart. Logic cannot deprive us of life, and religion is life to the religious. As an experience of consciousness it is beyond the assaults of logic. But the religious life is often projected in external forms —I use the word in its widest sense— and this embodiment of the religious sentiment will have to bear more and more, as the world becomes more enlightened, the stress of scientific tests. We must be careful of projecting into external nature that which belongs to ourselves. My critic commits this mistake: he feels, and takes delight in feeling, that I am struggling, and he obviously experiences the most exquisite pleasures of "the muscular sense" in holding me down. His feelings are as real as if his imagination of what mine are were equally real. His picture of my "struggles" is, however, a mere delusion. I do not struggle. I do not fear the charge of Atheism; nor should I even disavow it, in reference to any definition of the Supreme which he, or his order, would be likely to frame. His "links" and his "steel" and his "dread imputations" are, therefore, even more unsubstantial than my "streaks of morning cloud," and they may be permitted to vanish together.

* *

These minor and more purely personal matters at an end, the weightier allegation remains, that at Belfast I misused my position by quitting the domain of science, and making an unjustifiable raid into the domain of theology. This I fail to see. Laying aside abuse, I hope my accusers will consent to reason with me. Is it not lawful for a scientific man to speculate on the antecedents of the solar system? Did Kant, Laplace, and William Herschel quit their legitimate spheres when they prolonged the intellectual vision beyond the boundary of experience, and propounded the nebular theory? Accepting that theory as probable, is it not permitted to a scientific man to follow up, in idea, the series of changes associated with the condensation of the nebulæ; to picture the successive detachment of planets and moons, and the relation of all of them to the sun? If I look upon our earth, with its orbital revolution and axial rotation, as one small issue of the process which made the solar system what it is, will any theologian deny my right to entertain and express this theoretic view? Time was when a multitude of theologians would have been found to do so—when that arch-enemy of science which now vaunts its tolerance would have made a speedy end of the man who might venture to publish any opinion of the kind. But that time, unless the world is caught strangely slumbering, is for ever past.

As regards inorganic nature, then, we may traverse, without let or hindrance, the whole distance which separates the nebulæ from the worlds of to-day. But only a few years ago this now conceded ground of science was theological ground. I could by no means regard this as the final and sufficient concession of theology; and, at Belfast, I thought it not only my right but my duty to state that, as regards the organic world, we must enjoy the freedom which we have already won in regard to the inorganic. I could not discern the shred of a title-deed which gave any man, or any class of men, the right to open the door of one of these worlds to the scientific searcher and to

close the other against him. And I considered it frankest, wisest, and in the long run most conducive to permanent peace, to indicate, without evasion or reserve, the ground that belongs to Science, and to which she will assuredly make good her claim.

I have been reminded that an eminent predecessor of mine in the Presidential chair expressed a totally different view of the Cause of things from that enunciated by me. In doing so he transgressed the bounds of science at least as much as I did; but nobody raised an outcry against him. The freedom he took I claim. And looking at what I must regard as the extravagances of the religious world; at the very inadequate and foolish notions concerning this universe which are entertained by the majority of our authorised religious teachers; at the waste of energy on the part of good men over things unworthy, if I may say it without discourtesy, of the attention of enlightened heathens; the fight about the fripperies of Ritualism, and the verbal quibbles of the Athanasian Creed; the forcing on the public view of Pontigny Pilgrimages; the dating of historic epochs from the definition of the Immaculate Conception; the proclamation of the Divine Glories of the Sacred Heart—standing in the midst of these chimeras, which astound all thinking men, it did not appear to me extravagant to claim the public tolerance for an hour and a half, for the statement of more reasonable views, views more in accordance with the verities which science has brought to light, and which many weary souls would, I thought, welcome with gratification and relief.

But to come to closer quarters. The expression to which the most violent exception has been taken is this: "Abandoning all disguise, the confession I feel bound to make before you is that I prolong the vision backward across the boundary of the experimental evidence, and discern in that Matter which we, in our ignorance, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of every form and quality of life." To call it a "chorus of dissent," as my Catholic critic does, is a mild way of describing the storm of opprobrium with which this statement has been assailed. But the first blast of passion being past, I hope I may again ask my opponents to consent to reason. First of all, I am blamed for crossing the boundary of the experimental evidence. This, I reply, is the habitual action of the scientific mind—at least of that portion of it which applies itself to physical investigation. Our theories of light, heat, magnetism, and electricity, all imply the crossing of this boundary. My paper on the "Scientific Use of the Imagination," and my "Lectures on Light," illustrate this point in the amplest manner; and in the article entitled "Matter and Force" I have sought, incidentally, to make clear that in physics the experiential incessantly leads to the ultra-experiential; that out of experience there always grows something finer than mere experience, and that in their different powers of ideal extension consists, for the most part, the difference between the great and the mediocre investigator. The kingdom of science, then, cometh not by observation and experiment alone, but is completed by fixing the roots of observation and experiment in a region inaccessible to both, and in dealing with which we are forced to fall back upon the picturing power of the mind.

Passing the boundary of experience, therefore, does not, in the abstract, constitute a sufficient ground for censure. There must have been something in my particular mode of crossing it which provoked this tremendous "chorus of dissent."

Let us calmly reason the point out. I hold the nebular theory as it was held by Kant, Laplace, and William Herschel, and as it is held by the best scientific intellects of to-day. According to it, our sun and planets were once diffused through space as an impalpable haze, out of which, by condensation, came the solar system. What caused the haze to

condense? Loss of heat. What rounded the sun and planets? That which rounds a tear—molecular force. For æons, the immensity of which overwhelms man's conceptions, the earth was unfit to maintain what we call life. It is now covered with visible living things. They are not formed of matter different from that of the earth around them. They are, on the contrary, bone of its bone, and flesh of its flesh. How were they introduced? Was life implicated in the nebula—as part, it may be, of a vaster and wholly Unfathomable Life; or is it the work of a Being standing outside the nebula, who fashioned it, and vitalised it; but whose own origin and ways are equally past finding out? As far as the eye of science has hitherto ranged through nature, no intrusion of purely creative power into any series of phenomena has ever been observed. The assumption of such a power to account for special phenomena, though often made, has always proved a failure. It is opposed to the very spirit of science; and I therefore assumed the responsibility of holding up, in contrast with it, that method of nature which it has been the vocation and triumph of science to disclose, and in the application of which we can alone hope for further light. Holding, then, that the nebulæ and the solar system, life included, stand to each other in the relation of the germ to the finished organism, I reaffirm here, not arrogantly or defiantly, but without a shade of indistinctness, the position laid down at Belfast.

Not with the vagueness belonging to the emotions, but with the definiteness belonging to the understanding, the scientific man has to put to himself these questions regarding the introduction of life upon the earth. He will be the last to dogmatise upon the subject, for he knows best that certainty is here for the present unattainable. His refusal of the creative hypothesis is less an assertion of knowledge than a protest against the assumption of knowledge which must long, if not for ever, lie beyond us, and the claim to which is the source of perpetual confusion upon earth. With a mind open to conviction he asks his opponents to show him an authority for the belief they so strenuously and so fiercely uphold. They can do no more than point to the Book of Genesis, or some other portion of the Bible. Profoundly interesting, and indeed pathetic, to me are those attempts of the opening mind of man to appease its hunger for a Cause. But the Book of Genesis has no voice in scientific questions. To the grasp of geology, which it resisted for a time, it at length yielded like potter's clay; its authority as a system of cosmogony being discredited on all hands by the abandonment of the obvious meaning of its writer. It is a poem, not a scientific treatise. In the former aspect it is for ever beautiful: in the latter aspect it has been, and it will continue to be, purely obstructive and hurtful. To *knowledge* its value has been negative, leading, in rougher ages than ours, to physical, and even in our own "free age to moral, violence.

No incident connected with the proceedings at Belfast is more instructive than the deportment of the Catholic hierarchy of Ireland; a body usually too wise to confer notoriety upon an adversary by imprudently denouncing him. The *Times*, to which I owe a great deal on the score of fair play, where so much has been unfair, thinks that the Irish Cardinal, Archbishops, and Bishops, in a recent manifesto, adroitly employed a weapon which I, at an unlucky moment, placed in their hands. The antecedents of their action cause me to regard it in a different light; and a brief reference to these antecedents will, I think, illuminate not only their proceedings regarding Belfast, but other doings which have been recently noised abroad.

Before me lies a document bearing the date of November, 1873, which, after appearing for a moment, unaccountably vanished from public view. It is a Memorial addressed by seventy of the

Students and Ex-students of the Catholic University in Ireland to the Episcopal Board of the University; and it constitutes the plainest and bravest remonstrance ever addressed by Irish laymen to their spiritual pastors and masters. It expresses the profoundest dissatisfaction with the curriculum marked out for the students of the University, setting forth the extraordinary fact that the lecture-list for the faculty of Science, published a month before they wrote, did not contain the name of a single Professor of the Physical or Natural Sciences.

The memorialists forcibly deprecate this, and dwell upon the necessity of education in science: "The distinguishing mark of this age is its ardour for science. The natural sciences have, within the last fifty years, become the chiefest study in the world; they are in our time pursued with an activity unparalleled in the history of mankind. Scarce a year now passes without some discovery being made in these sciences which, as with the touch of the magician's wand, shivers to atoms theories formerly deemed unassailable. It is through the physical and natural sciences that the fiercest assaults are now made on our religion. No more deadly weapon is used against our faith than the facts incontestably proved by modern researches in science."

Such statements must be the reverse of comfortable to a number of gentlemen who, trained in the philosophy of Thomas Aquinas, have been accustomed to the unquestioning submission of all other sciences to their divine science of Theology. But this is not all: "One thing seems certain," say the memorialists, "viz., that if chairs for the physical and natural sciences be not soon founded in the Catholic University, very many young men will have their faith exposed to dangers which the creation of a school of science in the University would defend them from. For our generation of Irish Catholics are writhing under the sense of their inferiority in science, and are determined that such inferiority shall not long continue; and so, if scientific training be unattainable at our University, they will seek it at Trinity or at the Queen's Colleges, in not one of which is there a Catholic Professor of Science."

Those who imagined the Catholic University at Kensington to be due to the spontaneous recognition, on the part of the Roman hierarchy, of the intellectual needs of the age will derive enlightenment from this, and still more from what follows: for the most formidable threat remains. To the picture of Catholic students seceding to Trinity and the Queen's Colleges the memorialists add this darkest stroke of all: "They will, in the solitude of their own homes, unaided by any guiding advice, devour the works of Haeckel, Darwin, Huxley, Tyndall, and Lyell: works innocuous if studied under a professor who would point out the difference between established facts and erroneous inferences, but which are calculated to sap the faith of a solitary student deprived of a discriminating judgment to which he could refer for a solution of his difficulties."

In the light of the knowledge given by this courageous memorial, and of similar knowledge otherwise derived, the recent Catholic manifesto did not at all strike me as a chuckle over the mistake of a maladroit adversary, but rather as an evidence of profound uneasiness on the part of the Cardinal, the Archbishops, and the Bishops who signed it. They acted towards the Students' Memorial, however, with their accustomed practical wisdom. As one concession to the spirit which it embodied, the Catholic University at Kensington was brought forth, apparently as the effect of spontaneous inward force, and not of outward pressure becoming too formidable to be successfully opposed.

The memorialists point with bitterness to the fact that "the name of no Irish Catholic is known in connection with the physical and natural sciences." But this, they ought to know, is the complaint of free and cultivated minds wherever

a Priesthood exercises dominant power. Precisely the same complaint has been made with respect to the Catholics of Germany. The great national literature and the scientific achievements of that country, in modern times, are almost wholly the work of Protestants. A vanishingly small fraction of it only is derived from members of the Roman Church, although the number of these in Germany is at least as great as that of the Protestants. "The question arises," says a writer in an able German periodical, "what is the cause of a phenomenon so humiliating to the Catholics? It cannot be referred to want of natural endowment due to climate (for the Protestants of Southern Germany have contributed powerfully to the creations of the German intellect), but purely to outward circumstances. And these are readily discovered in the pressure exercised for centuries by the Jesuitical system, which has crushed out of Catholics every tendency to free mental productiveness." It is, indeed, in Catholic countries that the weight of Ultramontanism has been most severely felt. It is in such countries that the very finest spirits, who have dared, without quitting their faith, to plead for freedom or reform, have suffered extinction. The extinction, however, was more apparent than real, and Hermes, Hirscher, and Günther, though individually broken and subdued, prepared the way, in Bavaria, for the persecuted but unflinching Frohschammer, for Döllinger, and for the remarkable liberal movement of which Döllinger is the head and guide.

Though moulded for centuries to an obedience unparalleled in any other country, except Spain, the Irish intellect is beginning to show signs of independence; demanding a diet more suited to its years than the pabulum of the Middle Ages. As for the recent manifesto in which Pope, Cardinal, Archbishops, and Bishops are united in one grand anathema, its character and faith are shadowed forth by the Vision of Nebuchadnezzar recorded in the Book of Daniel. It resembles the image whose form was terrible, but the gold, and silver, and brass, and iron of which rested upon feet of clay. And a stone smote the feet of clay; and the iron, and the brass, and the silver, and the gold, were broken in pieces together, and became like the chaff of the summer threshing-floors, and the wind carried them away.

Monsignor Capel has recently been good enough to proclaim at once the friendliness of his Church towards true science, and her right to determine what true science is. Let us dwell for a moment on the proofs of her scientific competence. When Halley's comet appeared in 1456 it was regarded as the harbinger of God's vengeance, the dispenser of war, pestilence, and famine, and by order of the Pope the church bells of Europe were rung to scare the monster away. An additional daily prayer was added to the supplications of the faithful. The comet in due time disappeared, and the faithful were comforted by the assurance that, as in previous instances relating to eclipses, droughts, and rains, so also as regards this "nefarious" comet, victory had been vouchsafed to the Church.

Both Pythagoras and Copernicus had taught the heliocentric doctrine—that the earth revolves round the sun. In the exercise of her right to determine what true science is, the Church, in the Pontificate of Paul V., stepped in and, by the mouth of the Holy Congregation of the Index, delivered, on March 5th, 1616, the following decree:—

And whereas it hath also come to the knowledge of the said Holy Congregation that the false Pythagorean doctrine of the mobility of the earth and the immobility of the sun, entirely opposed to Holy writ, which is taught by Nicolas Copernicus, is now published abroad and received by many. In order that this opinion may not further spread, to the damage of Catholic truth, it is ordered that this and all other books teaching the like doctrine be suspended, and by this decree they are all respectively suspended, forbidden, and condemned.

But why go back to 1456 and 1616? Far be it from me to charge bygone sins upon Monsignor Capel, were it not for the practices he upholds to-day. The most applauded dogmatist and champion of the Jesuits is, I am informed, Perrone. No less than thirty editions of a work of his have been scattered abroad for the healing of the nations. His notions of physical astronomy are virtually those of 1456. He teaches boldly that "God does not rule by universal law......that when God orders a given planet to stand still He does not detract from any law passed by Himself, but orders that planet to move round the sun for such and such a time, then to stand still, and then again to move, as His pleasure may be." Jesuitism proscribed Frohschammer for questioning its favourite dogma, that every human soul was created by a direct supernatural act of God, and for asserting that man, body and soul, came from his parents. This is the system that now strives for universal power; it is from it, as Monsignor Capel graciously informs us, that we are to learn what is allowable in science, and what is not!

In the face of such facts, which might be multiplied at will, it requires extraordinary bravery of mind, or a reliance upon public ignorance almost as extraordinary, to make the claims made by Monsignor Capel for his Church.

Before me is a very remarkable letter addressed in 1875[1] by the Bishop of Montpellier to the Deans and Professors of Faculties of Montpellier, in which the writer very clearly lays down the claims of his Church. He had been startled by an incident occurring in a course of lectures on Physiology given by a professor, of whose scientific capacity there was no doubt, but who, it was alleged, rightly or wrongly, had made his course the vehicle of materialism. "Je ne me suis point donné," says the Bishop, "la mission que je remplis au milieu de vous. 'Personne, au temoignage de saint Paul, ne s'attribue à soi-même un pareil honneur; il y faut être appelé de Dieu, comme Aaron.' Et pourquoi en est-il ainsi? C'est parce que, selon le même Apôtre, nous devons être les ambassadeurs de Dieu; et il n'est pas dans les usages, pas plus qu'il n'est dans la raison et le droit, qu'un envoyé s'accrédite lui-meme. Mais, si j'ai reçu d'En-Haut une mission; si l'Eglise, au nom de Dieu lui-même, a souscrit mes lettres de créance, me siérait-il de manquer aux instructions qu'elle m'a données et d'entendre, en un sens différent du sien, le rôle qu'elle m'a confié?

"Or, Messieurs, la sainte Eglise se croit investie du droit absolu d'enseigner les hommes; elle se croit dépositaire de la vérité, non pas de la vérité fragmentaire, incomplète, mêlée de certitude et d'hésitation, mais de la vérité totale, complète, au point de vue religieux. Bien plus, elle est si sûre de l'infaillibilité que son Fondateur divin lui a communiquée, comme la dot magnifique de leur indissoluble alliance, que, même dans l'ordre naturel, scientifique ou philosophique, moral ou politique, elle n'admet pas qu'un système puisse être soutenu et adopté par des chrétiens, s'il contredit à des dogmes définis. Elle considère que la négation volontaire et opiniâtre d'un seul point de sa doctrine rend coupable du péché d'hérésie; et elle pense que toute hérésie formelle, si on ne la rejette pas courageusement avant de paraître devant Dieu, entraîne avec soi la perte certaine de la grâce et de l'éternité."

The Bishop recalls those whom he addresses from the false philosophy of the present to the philosophy of the past, and foresees the triumph of the latter. "Avant que le dix-neuvième siècle s'achève, la vieille philosophie scolastique aura repris sa place dans la juste admiration du monde. Il lui faudra pourtant bien du temps pour guérir les maux de tout genre, causés par son indigne rivale; et pendant de longues années encore, ce nom de *philosophie*, le

[1] The next four paragraphs, as this date indicates, were inserted only in the subsequent reprints.—ED.

plus grand de la langue humaine après celui de *religion*, sera suspect aux âmes qui se souviendront de la science impie et matérialiste de Locke, de Condillac ou d'Helvétius. L'heure actuelle est aux sciences naturelles : c'est maintenant l'instrument de combat contre l'Eglise et contre toute foi religieuse. Nous ne les redoutons pas." Further on the Bishop warns his readers that everything can be abused. Poetry is good, but in excess it may injure practical conduct. "Les mathématiques sont excellentes : et Bossuet les a louées 'comme étant ce qui sert le plus à la justesse du raisonnement'; mais si on s'accoutume exclusivement à leur méthode, rien de ce qui appartient à l'ordre moral ne paraît plus pouvoir être démontré ; et Fénelon a pu parler de *l'ensorcellement* et des attraits *diaboliques* de la géométrie."

The learned Bishop thus finally accentuates the claims of the Church :—"Comme le définissait le Pape Léon X, au cinquième concile œcuménique de Latran, 'Le vrai ne peut pas être contraire à lui-même : par conséquent, toute assertion contraire à une vérité de foi révélée est nécessairement et absolument fausse.' Il suit de là que, sans entrer dans l'examen scientifique de telle ou telle question de physiologie, mais par la seule certitude de nos dogmes, nous pouvons juger du sort de telle ou telle hypothèse, qui est une machine de guerre anti-chrétienne plutôt qu'une conquête sérieuse sur les secrets et les mystères de la nature....... C'est un dogme que l'homme a été formé et façonné des mains de Dieu. Donc il est faux, hérétique, contraire à la dignité du Créateur et offensant pour son chef-d'œuvre, de dire que l'homme constitue la *septième* espèce des singes. ......Hérésie encore de dire que le genre humain n'est pas sorti d'un seul couple, et qu'on y peut compter jusqu'à *douze* races distinctes !"

The course of life upon earth, as far as Science can see, has been one of amelioration—a steady advance on the whole from the lower to the higher. The continued effort of animated nature is to improve its condition and raise itself to a loftier level. In man improvement and amelioration depend largely upon the growth of conscious knowledge, by which the errors of ignorance are continually moulted, and truth is organised. It is the advance of knowledge that has given a materialistic colour to the philosophy of this age. Materialism is therefore not a thing to be mourned over, but to be honestly considered—accepted if it be wholly true, rejected if it be wholly false, wisely sifted and turned to account if it embrace a mixture of truth and error. Of late years the study of the nervous system, and its relation to thought and feeling, have profoundly occupied inquiring minds. It is our duty not to shirk—it ought rather to be our privilege to accept—the established results of such inquiries, for here assuredly our ultimate weal depends upon our loyalty to the truth. Instructed as to the control which the nervous system exercises over man's moral and intellectual nature, we shall be better prepared, not only to mend their manifold defects, but also to strengthen and purify both. Is mind degraded by this recognition of its dependence? Assuredly not. Matter, on the contrary, is raised to the level it ought to occupy, and from which timid ignorance would remove it.

But the light is dawning, and it will become stronger as time goes on. Even the Brighton "Church Congress" affords evidence of this. From the manifold confusions of that assemblage my memory has rescued two items, which it would fain preserve : the recognition of a relation between Health and Religion, and the address of the Rev. Harry Jones. Out of the conflict of vanities his words emerge wholesome and strong, because undrugged by dogma, coming directly from the warm brain of one who knows what practical truth means, and who has faith in its vitality and inherent power of propagation. I wonder whether he is less effectual in his ministry than his more embroidered colleagues? It surely

behoves our teachers to come to some definite understanding as to this question of health; to see how, by inattention to it, we are defrauded, negatively and positively; negatively, by the privation of that "sweetness and light" which is the natural concomitant of good health; positively, by the insertion into life of cynicism, ill-temper, and a thousand corroding anxieties which good health would dissipate. We fear and scorn "materialism." But he who knew all about it, and could apply his knowledge, might become the preacher of a new gospel. Not, however, through the ecstatic moments of the individual does such knowledge come, but through the revelations of science, in connection with the history of mankind.

Why should the Roman Catholic Church call gluttony a mortal sin? Why should fasting occupy a place in the disciplines of religion? What is the meaning of Luther's advice to the young clergyman who came to him, perplexed with the difficulties of predestination and election, if it be not that, in virtue of its action upon the brain, when wisely applied, there is moral and religious virtue even in a hydro-carbon? To use the old language, food and drink are creatures of God, and have therefore a spiritual value. Through our neglect of the monitions of a reasonable materialism we sin and suffer daily. I might here point to the train of deadly disorders over which science has given modern society such control—disclosing the lair of the material enemy, ensuring his destruction, and thus preventing that moral squalor and hopelessness which habitually tread on the heels of epidemics in the case of the poor.

Rising to higher spheres, the visions of Swedenborg, and the ecstasy of Plotinus and Porphyry, are phases of that psychical condition, obviously connected with the nervous system and state of health, on which is based the Vedic doctrine of the absorption of the individual into the universal soul. Plotinus taught the devout how to pass into a condition of ecstasy. Porphyry complains of having been only once united to God in eighty-six years, while his master Plotinus had been so united six times in sixty years.[1] A friend who knew Wordsworth informs me that the poet, in some of his moods, was accustomed to seize hold of an external object to assure himself of his own bodily existence. As states of consciousness such phenomena have an undisputed reality and a substantial identity; but they are connected with the most heterogeneous objective conceptions. The subjective experiences are similar, because of the similarity of the underlying organisations.

But for those who wish to look beyond the practical facts there will always remain ample room for speculation. Take the argument of the Lucretian introduced in the Belfast Address. As far as I am aware, not one of my assailants has attempted to answer it. Some of them, indeed, rejoice over the ability displayed by Bishop Butler in rolling back the difficulty on his opponent; and they even imagine that it is the Bishop's own argument that is there employed. But the raising of a new difficulty does not abolish—does not even lessen—the old one, and the argument of the Lucretian remains untouched by anything the Bishop has said or can say.

And here it may be permitted me to add a word to an important controversy now going on: and which turns on the question: Do states of consciousness enter as links into the chain of antecedence and sequence, which give rise to bodily actions, and to other states of consciousness; or are they merely *by-products*, which are not essential to the physical processes going on in the brain? Speaking for myself, it is certain that I have no power of imagining states of

[1] I recommend to the reader's particular attention Dr. Draper's important work entitled *History of the Conflict between Religion and Science* (Messrs. H. S. King and Co.).

consciousness, interposed between the molecules of the brain, and influencing the transference of motion among the molecules. The thought "eludes all mental presentation"; and hence the logic seems of iron strength which claims for the brain an automatic action, uninfluenced by states of consciousness. But it is, I believe, admitted by those who hold the automaton-theory, that states of consciousness are *produced* by the marshalling of the molecules of the brain: and this production of consciousness by molecular motion is to me quite as inconceivable on mechanical principles as the production of molecular motion by consciousness. If, therefore, I reject one result, I must reject both. I, however, reject neither, and thus stand in the presence of two Incomprehensibles, instead of one Incomprehensible. While accepting fearlessly the facts of materialism dwelt upon in these pages, I bow my head in the dust before that mystery of mind which has hitherto defied its own penetrative power, and which may ultimately resolve itself into a demonstrable impossibility of self-penetration.

But the secret is an open one—the practical monitions are plain enough, which declare that on our dealings with matter depend our weal and woe, physical and moral. The state of mind which rebels against the recognition of the claims of "materialism" is not unknown to me. I can remember a time when I regarded my body as a weed, so much more highly did I prize the conscious strength and pleasure derived from moral and religious feeling—which, I may add, was mine without the intervention of dogma. The error was not an ignoble one, but this did not save it from the penalty attached to error. Saner knowledge taught me that the body is no weed, and that, treated as such, it would infallibly avenge itself. Am I personally lowered by this change of front? Not so. Give me their health, and there is no spiritual experience of those earlier years—no resolve of duty, or work of mercy, no work of self-renouncement, no solemnity of thought, no joy in the life and aspects of nature—that would not still be mine; and this without the least reference or regard to any purely personal reward or punishment looming in the future.

And now I have to utter a "farewell" free from bitterness to all my readers; thanking my friends for a sympathy more steadfast, I would fain believe, if less noisy, than the antipathy of my foes; and commending to these a passage from Bishop Butler, which they have either not read or failed to lay to heart. "It seems," saith the Bishop, "that men would be strangely headstrong and self-willed, and disposed to exert themselves with an impetuosity which would render society insupportable, and the living in it impracticable, were it not for some acquired moderation and self-government, some aptitude and readiness in restraining themselves, and concealing their sense of things."

SCIENTIFIC MATERIALISM[1]

1868

THE celebrated Fichte, in his lectures on the "Vocation of the Scholar," insisted on a culture which should be not one-sided, but all-sided. The scholar's intellect was to expand spherically, and not in a single direction only. In one direction, however, Fichte required that the scholar should apply himself directly to nature, become a creator of knowledge, and thus repay, by original labours of his own, the immense debt he owed to the labours of others. It was these which enabled him to supplement the knowledge derived from his own researches, so as to render his culture rounded and not one-sided.

As regards science, Fichte's idea is to some extent illustrated by the constitution and labours of the British Association. We have here a body of men engaged in the pursuit of Natural Knowledge, but variously engaged. While sympathising with each of its departments, and supplementing his culture by knowledge drawn from all of them, each student amongst us selects one subject for the exercise of his own original faculty—one line, along which he may carry the light of his private intelligence a little way into the darkness by which all knowledge is surrounded. Thus, the geologist deals with the rocks; the biologist with the conditions and phenomena of life; the astronomer with stellar masses and motions; the mathematician with the relations of space and number; the chemist pursues his atoms; while the physical investigator has his own large field in optical, thermal, electrical, acoustical, and other phenomena. The British Association then, as a whole, faces physical nature on all sides, and pushes knowledge centrifugally outwards, the sum of its labours constituting what Fichte might call the *sphere* of natural knowledge. In the meetings of the Association it is found necessary to resolve this sphere into its component parts, which take concrete form under the respective letters of our Sections.

Mathematics and Physics have been long accustomed to coalesce, and here they form a single section. No matter how subtle a natural phenomenon may be, whether we observe it in the region of sense or follow it into that of imagination, it is in the long run reducible to mechanical laws. But the mechanical data once guessed or given, mathematics are all-powerful as an instrument of deduction. The command of Geometry over the relations of space, and the far-reaching power which Analysis confers, are potent both as means of physical discovery and of reaping the entire fruits of discovery. Indeed, without mathematics, expressed or implied, our knowledge of physical science would be both friable and incomplete.

Side by side with the mathematical method we have the method of experiment. Here, from a starting-point furnished by his own researches or those of others, the investigator proceeds by combining intuition and verification. He ponders the knowledge he possesses, and tries to push it further; he guesses, and checks his guess; he conjectures, and confirms or explodes his conjecture. These guesses and conjectures are by no means leaps in the dark; for knowledge once gained casts a faint light beyond its own immediate boundaries. There is no discovery so limited as not to

[1] President's Address to the Mathematical and Physical Section of the British Association at Norwich.

illuminate something beyond itself. The force of intellectual penetration into this penumbral region which surrounds actual knowledge is not, as some seem to think, dependent upon method, but upon the genius of the investigator. There is, however, no genius so gifted as not to need control and verification. The profoundest minds know best that Nature's ways are not at all times their ways, and that the brightest flashes in the world of thought are incomplete until they have been proved to have their counterparts in the world of fact. Thus the vocation of the true experimentalist may be defined as the continued exercise of spiritual insight, and its incessant correction and realisation. His experiments constitute a body, of which his purified intuitions are, as it were, the soul.

Partly through mathematical and partly through experimental research, physical science has, of late years, assumed a momentous position in the world. Both in a material and in an intellectual point of view it has produced, and it is destined to produce, immense changes—vast social ameliorations, and vast alterations in the popular conception of the origin, rule, and governance of natural things. By science, in the physical world, miracles are wrought, while philosophy is forsaking its ancient metaphysical channels, and pursuing others which have been opened or indicated by scientific research. This must become more and more the case as philosophical writers become more deeply imbued with the methods of science, better acquainted with the facts which scientific men have established, and with the great theories which they have elaborated.

If you look at the face of a watch, you see the hour and minute-hands, and possibly also a second-hand, moving over the graduated dial. Why do these hands move; and why are their relative motions such as they are observed to be? These questions cannot be answered without opening the watch, mastering its various parts, and ascertaining their relationship to each other. When this is done, we find that the observed motion of the hands follows of necessity from the inner mechanism of the watch when acted upon by the force invested in the spring. The motion of the hands may be called a phenomenon of art, but the case is similar with the phenomena of nature. These also have their inner mechanism and their store of force to set that mechanism going. The ultimate problem of physical science is to reveal this mechanism, to discern this store, and to show that, from the combined action of both, the phenomena of which they constitute the basis must, of necessity, flow.

I thought an attempt to give you even a brief and sketchy illustration of the manner in which scientific thinkers regard this problem would not be uninteresting to you on the present occasion; more especially as it will give me occasion to say a word or two on the tendencies and limits of modern science; to point out the region which men of science claim as their own, and where it is futile to oppose their advance; and also to define, if possible, the bourne between this and that other region to which the questionings and yearnings of the scientific intellect are directed in vain.

But here your tolerance will be needed. It was the American Emerson, I think, who said that it is hardly possible to state any truth strongly, without apparent injustice to some other truth. Truth is often of a dual character, taking the form of a magnet with two poles; and many of the differences which agitate the thinking part of mankind are to be traced to the exclusiveness with which partisan reasoners dwell upon one half of the duality, in forgetfulness of the other. The proper course appears to be to state both halves strongly, and allow each its fair share in the formation of the resultant conviction. But this waiting for the statement of the two sides of a question implies patience. It implies a resolution to suppress indignation, if the statement of the one half should clash with our

convictions, and to repress equally undue elation, if the half-statement should happen to chime in with our views. It implies a determination to wait calmly for the statement of the whole before we pronounce judgment in the form of either acquiescence or dissent.

This premised, and I trust accepted, let us enter upon our task. There have been writers who affirmed that the Pyramids of Egypt were natural productions; and in his early youth Alexander von Humboldt wrote a learned essay with the express object of refuting this notion. We now regard the pyramids as the work of men's hands, aided probably by machinery of which no record remains. We picture to ourselves the swarming workers toiling at those vast erections, lifting the inert stones, and, guided by the volition, the skill, and possibly at times by the whip of the architect, placing them in their proper positions. The blocks, in this case, were moved and posited by a power external to themselves, and the final form of the pyramid expressed the thought of its human builder.

Let us pass from this illustration of constructive power to another of a different kind. When a solution of common salt is slowly evaporated, the water which holds the salt in solution disappears, but the salt itself remains behind. At a certain stage of concentration the salt can no longer retain the liquid form; its particles, or molecules, as they are called, begin to deposit themselves as minute solids—so minute, indeed, as to defy all microscopic power. As evaporation continues, solidification goes on, and we finally obtain, through the clustering together of innumerable molecules, a finite crystalline mass of a definite form. What is this form? It sometimes seems a mimicry of the architecture of Egypt. We have little pyramids built by the salt, terrace above terrace from base to apex, forming a series of steps resembling those up which the traveller in Egypt is dragged by his guides. The human mind is as little disposed to look without questioning at these pyramidal salt-crystals as to look at the pyramids of Egypt, without inquiring whence they came. How, then, are those salt-pyramids built up?

Guided by analogy, you may, if you like, suppose that, swarming among the constituent molecules of the salt, there is an invisible population, controlled and coerced by some invisible master, placing the atomic blocks in their positions. This, however, is not the scientific idea, nor do I think your good sense will accept it as a likely one. The scientific idea is that the molecules act upon each other without the intervention of slave labour; that they attract each other, and repel each other, at certain definite points or poles, and in certain definite directions; and that the pyramidal form is the result of this play of attraction and repulsion. While, then, the blocks of Egypt were laid down by a power external to themselves, these molecular blocks of salt are self-posited, being fixed in their places by the inherent forces with which they act upon each other.

I take common salt as an illustration, because it is so familiar to us all; but any other crystalline substance would answer my purpose equally well. Everywhere, in fact, throughout inorganic nature, we have this formative power, as Fichte would call it—this structural energy ready to come into play, and build the ultimate particles of matter into definite shapes. The ice of our winters and of our polar regions is its handiwork, and so also are the quartz, felspar, and mica of our rocks. Our chalk-beds are for the most part composed of minute shells, which are also the product of structural energy; but behind the shell, as a whole, lies a more remote and subtle formative act. These shells are built up of little crystals of calc-spar, and, to form these crystals, the structural force had to deal with the intangible molecules of carbonate of line. This tendency on the part of matter to organise itself, to grow into shape, to assume definite forms in obedience to the definite action of force, is, as I have said, all-

pervading. It is in the ground on which you tread, in the water you drink, in the air you breathe. Incipient life, as it were, manifests itself throughout the whole of what we call inorganic nature.

The forms of the minerals resulting from this play of polar forces are various, and exhibit different degrees of complexity. Men of science avail themselves of all possible means of exploring their molecular architecture. For this purpose they employ in turn, as agents of exploration, light, heat, magnetism, electricity, and sound. Polarised light is especially useful and powerful here. A beam of such light, when sent in among the molecules of a crystal, is acted on by them, and from this action we infer with more or less clearness the manner in which the molecules are arranged. That differences, for example, exist between the inner structure of rock-salt and that of crystallised sugar or sugar-candy is thus strikingly revealed. These actions often display themselves in chromatic phenomena of great splendour, the play of molecular force being so regulated as to cause the removal of some of the coloured constituents of white light, while others are left with increased intensity behind.

And now let us pass from what we are accustomed to regard as a dead mineral, to a living grain of corn. When this is examined by polarised light, chromatic phenomena similar to those noticed in crystals are observed. And why? Because the architecture of the grain resembles that of the crystal. In the grain also the molecules are set in definite positions, and in accordance with their arrangement they act upon the light. But what has built together the molecules of the corn? Regarding crystalline architecture, I have already said that you may, if you please, consider the atoms and molecules to be placed in position by a Power external to themselves. The same hypothesis is open to you now. But if in the case of crystals you have rejected this notion of an external architect, I think you are bound to reject it in the case of the grain, and to conclude that the molecules of the corn, also, are posited by the forces with which they act upon each other. It would be poor philosophy to invoke an external agent in the one case, and to reject it in the other.

Instead of cutting our grain of corn into slices and subjecting it to the action of polarised light, let us place it in the earth, and subject it to a certain degree of warmth. In other words, let the molecules, both of the corn and of the surrounding earth, be kept in that state of agitation which we call heat. Under these circumstances, the grain and the substances which surround it interact, and a definite molecular architecture is the result. A bud is formed; this bud reaches the surface, where it is exposed to the sun's rays, which are also to be regarded as a kind of vibratory motion. And as the motion of common heat, with which the grain and the substances surrounding it were first endowed, enabled the grain and these substances to exercise their mutual attractions and repulsions, and thus to coalesce in definite forms, so the specific motion of the sun's rays now enables the green bud to feed upon the carbonic acid and the aqueous vapour of the air. The bud appropriates those constituents of both for which it has an elective attraction, and permits the other constituent to return to the atmosphere. Thus the architecture is carried on. Forces are active at the root, forces are active in the blade, the matter of the air and the matter of the atmosphere are drawn upon, and the plant augments in size. We have in succession the stalk, the ear, the full corn in the ear; the cycle of molecular action being completed by the production of grains similar to that with which the process began.

Now there is nothing in this process which necessarily eludes the conceptive or imagining power of the human mind. An intellect the same in kind as our own would, if only sufficiently expanded, be able to follow the whole process from

beginning to end. It would see every molecule placed in its position by the specific attractions and repulsions exerted between it and other molecules, the whole process, and its consummation, being an instance of the play of molecular force. Given the grain and its environment, with their respective forces, the purely human intellect might, if sufficiently expanded, trace out *a priori* every step of the process of growth, and, by the application of purely mechanical principles, demonstrate that the cycle must end, as it is seen to end, in the reproduction of forms like that with which it began. A necessity rules here, similar to that which rules the planets in their circuits round the sun.

You will notice that I am stating the truth strongly, as at the beginning we agreed it should be stated. But I must go still further, and affirm that in the eye of science the animal body is just as much the product of molecular force as the chalk and the ear of corn, or as the crystal of salt or sugar. Many of the parts of the body are obviously mechanical. Take the human heart, for example, with its system of valves, or take the exquisite mechanism of the eye or hand. Animal heat, moreover, is the same in kind as the heat of a fire, being produced by the same chemical process. Animal motion, too, is as certainly derived from the food of the animal as the motion of Trevethyck's walking-engine from the fuel in its furnace. As regards matter, the animal body creates nothing; as regards force, it creates nothing. Which of you by taking thought can add one cubit to his stature? All that has been said, then, regarding the plant may be restated with regard to the animal. Every particle that enters into the composition of a nerve, a muscle, or a bone has been placed in its position by molecular force. And unless the existence of law in these matters be denied, and the element of caprice introduced, we must conclude that, given the relation of any molecule of the body to its environment, its position in the body might be determined mathematically. Our difficulty is not with the *quality* of the problem, but with its *complexity;* and this difficulty might be met by the simple expansion of the faculties we now possess. Given this expansion, with the necessary molecular data, and the chick might be deduced as rigorously and as logically from the egg as the existence of Neptune from the disturbances of Uranus, or as conical refraction from the undulatory theory of light.

You see I am not mincing matters, but avowing nakedly what many scientific thinkers more or less distinctly believe. The formation of a crystal, a plant, or an animal is, in their eyes, a purely mechanical problem, which differs from the problems of ordinary mechanics in the smallness of the masses, and the complexity of the processes involved. Here you have one half of our dual truth; let us now glance at the other half. Associated with this wonderful mechanism of the animal body we have phenomena no less certain than those of physics, but between which and the mechanism we discern no necessary connection. A man, for example, can say "I feel," "I think," "I love"; but how does *consciousness* infuse itself into the problem? The human brain is said to be the organ of thought and feeling: when we are hurt, the brain feels it; when we ponder, or when our passions or affections are excited, it is through the instrumentality of the brain. Let us endeavour to be a little more precise here. I hardly imagine there exists a profound scientific thinker, who has reflected upon the subject, unwilling to admit the extreme probability of the hypothesis, that for every fact of consciousness, whether in the domain of sense, thought, or emotion, a definite molecular condition, of motion or structure, is set up in the brain; or who would be disposed even to deny that, if the motion, or structure, be induced by internal causes instead of external, the effect on consciousness will be the same?

Let any nerve, for example, be thrown by morbid action into the precise state of motion which would be communicated to it by the pulses of a heated body, surely that nerve will declare itself hot—the mind will accept the subjective intimation exactly as if it were objective. The retina may be excited by purely mechanical means. A blow on the eye causes a luminous flash, and the mere pressure of the finger on the external ball produces a star of light, which Newton compared to the circles on a peacock's tail. Disease makes people see visions and dream dreams; but, in all such cases, could we examine the organs implicated, we should, on philosophical grounds, expect to find them in that precise molecular condition which the real objects, if present, would superinduce.

The relation of physics to consciousness being thus invariable, it follows that, given the state of the brain, the corresponding thought or feeling might be inferred: or, given the thought or feeling, the corresponding state of the brain might be inferred. But how inferred? It would be at bottom not a case of logical inference at all, but of empirical association. You may reply that many of the inferences of science are of this character—the inference, for example, that an electric current, of a given direction, will deflect a magnetic needle in a definite way. But the cases differ in this, that the passage from the current to the needle, if not demonstrable, is conceivable, and that we entertain no doubt as to the final mechanical solution of the problem. But the passage from the physics of the brain to the corresponding facts of consciousness is inconceivable as a result of mechanics. Granted that a definite thought and a definite molecular action in the brain occur simultaneously, we do not possess the intellectual organ, nor apparently any rudiment of the organ, which would enable us to pass, by a process of reasoning, from the one to the other. They appear together, but we do not know why. Were our minds and senses so expanded, strengthened, and illuminated, as to enable us to see and feel the very molecules of the brain; were we capable of following all their motions, all their groupings, all their electric discharges, if such there be; and were we intimately acquainted with the corresponding states of thought and feeling; we should be as far as ever from the solution of the problem, "How are these physical processes connected with the facts of consciousness?" The chasm between the two classes of phenomena would still remain intellectually impassable. Let the consciousness of love, for example, be associated with a right-handed spiral motion of the molecules of the brain, and the consciousness of hate with a left-handed spiral motion. We should then know, when we love, that the motion is in one direction, and, when we hate, that the motion is in the other; but the "WHY?" would remain as unanswerable as before.

In affirming that the growth of the body is mechanical, and that thought, as exercised by us, has its correlative in the physics of the brain, I think the position of the "Materialist" is stated, as far as that position is a tenable one. I think the materialist will be able finally to maintain this position against all attacks; but I do not think, in the present condition of the human mind, that he can pass beyond this position. I do not think he is entitled to say that his molecular groupings and motions explain everything. In reality they explain nothing. The utmost he can affirm is the association of two classes of phenomena, of whose real bond of union he is in absolute ignorance. The problem of the connection of body and soul is as insoluble in its modern form as it was in the prescientific ages. Phosphorus is known to enter into the composition of the human brain, and a trenchant German writer has exclaimed, "Ohne Phosphor, kein Gedanke!" That may or may not be the case; but even if we knew it to be the case, the knowledge would not lighten our darkness. On both sides of the zone

here assigned to the materialist he is equally helpless. If you ask him whence is this "Matter" of which we have been discoursing, who or what divided it into molecules, who or what impressed upon them this necessity of running into organic forms, he has no answer. Science is mute in reply to these questions. But if the materialist is confounded and science rendered dumb, who else is prepared with a solution? To whom has this arm of the Lord been revealed? Let us lower our heads and acknowledge our ignorance, priest and philosopher, one and all.

Perhaps the mystery may resolve itself into knowledge at some future day. The process of things upon this earth has been one of amelioration. It is a long way from the Iguanodon and his contemporaries to the President and Members of the British Association. And whether we regard the improvement from the scientific or from the theological point of view—as the result of progressive development, or of successive exhibitions of creative energy—neither view entitles us to assume that man's present faculties end the series, that the process of amelioration ends with him. A time may therefore come when this ultra-scientific region, by which we are now enfolded, may offer itself to terrestrial, if not to human, investigation. Two-thirds of the rays emitted by the sun fail to arouse the sense of vision. The rays exist, but the visual organ requisite for their translation into light does not exist. And so, from this region of darkness and mystery which surrounds us, rays may now be darting, which require but the development of the proper intellectual organs to translate them into knowledge as far surpassing ours as ours surpasses that of the wallowing reptiles which once held possession of this planet. Meanwhile the mystery is not without its uses. It certainly may be made a power in the human soul; but it is a power which has feeling, not knowledge, for its base. It may be, will be, and I hope is turned to account, both in steadying and strengthening the intellect, and in rescuing man from that littleness to which, in the struggle for existence, or for precedence in the world, he is continally prone.

Musings on the Matterhorn, July 27th, 1868.

HACKED and hurt by time, the aspect of the mountain from its higher crags saddened me. Hitherto the impression it made was that of savage strength; here we had inexorable decay. But this notion of decay implied a reference to a period when the Matterhorn was in the full strength of mountainhood. Thought naturally ran back to its remoter origin and sculpture. Nor did thought halt there, but wandered on through molten worlds to that nebulous haze which philosophers have regarded, and with good reason, as the proximate source of all material things. I tried to look at this universal cloud, containing within itself the prediction of all that has since occurred; I tried to imagine it as the seat of those forces whose action was to issue in solar and stellar systems, and all that they involve. Did that formless fog contain potentially the *sadness* with which I regarded the Matterhorn? Did the *thought* which now ran back to it simply return to its primeval home? If so, had we not better recast our definitions of matter and force; for, if life and thought be the very flower of both, any definition which omits life and thought must be inadequate, if not untrue. Are questions like these warranted? Why not? If the final goal of man has not been yet attained; if his development has not been yet arrested, who can say that such yearnings and questionings are not necessary to the opening of a finer vision, to the budding and the growth of diviner powers? When I look at the heavens and the earth, at my own body, at my strength and weakness, even at these ponderings, and ask myself, Is

there no being or thing in the universe that knows more about these matters than I do; what is my answer? Supposing our theologic schemes of creation, condemnation, and redemption to be dissipated; and the warmth of denial which they excite, and which, as a motive force, can match the warmth of affirmation, dissipated at the same time; would the undeflected human mind return to the meridian of absolute neutrality as regards these ultra-physical questions? Is such a position one of stable equilibrium? The channels of thought being already formed, such are the questions, without replies, which could run athwart consciousness during a ten minutes' halt upon the weathered crest of the Matterhorn.

SCIENTIFIC USE OF THE IMAGINATION[1]

"Lastly, physical investigation, more than anything besides, helps to teach us the actual value and right use of the Imagination—of that wondrous faculty which, left to ramble uncontrolled, leads us astray into a wilderness of perplexities and errors, a land of mists and shadows; but which, properly controlled by experience and reflection, becomes the noblest attribute of man; the source of poetic genius, the instrument of discovery in Science, without the aid of which Newton would never have invented fluxions, nor Davy have decomposed the earths and alkalies, nor would Columbus have found another Continent."—Address to the Royal Society by its President, Sir Benjamin Brodie, Nov. 30th, 1859.

I CARRIED with me to the Alps this year the burden of this evening's work. Save from memory I had no direct aid upon the mountains; but to spur up the emotions, on which so much depends, as well as to nourish indirectly the intellect and will, I took with me four works, comprising two volumes of poetry, Goethe's *Farbenlehre*, and the work on *Logic* recently published by Mr. Alexander Bain. In Goethe, so noble otherwise, I chiefly noticed the self-inflicted hurts of genius, as it broke itself in vain against the philosophy of Newton. Mr. Bain I found, for the most part, learned and practical, shining generally with a dry light, but exhibiting at times a flush of emotional strength, which proved that even logicians share the common fire of humanity. He interested me most when he became the mirror of my own condition. Neither intellectually nor socially is it good for man to be alone, and the sorrows of thought are more patiently borne when we find that they have been experienced by another. From certain passages in his book I could infer that Mr. Bain was no stranger to such sorrows. Speaking, for example, of the ebb of intellectual force, which we all from time to time experience, Mr. Bain says: "The uncertainty where to look for the next opening of discovery brings the pain of conflict and debility of indecision." These words have in them the true ring of personal experience. The action of the investigator is periodic. He grapples with a subject of inquiry, wrestles with it, and exhausts, it may be, both himself and it for the time being. He breathes a space, and then renews the struggle in another field. Now this period of halting between two investigations is not always one of pure repose. It is often a period of doubt and discomfort—of gloom and *ennui*. "The uncertainty where to look for the next opening of discovery brings the pain of

[1] Discourse delivered before the British Association at Liverpool, September 16th, 1870.

conflict and the debility of indecision." It was under such conditions that I had to equip myself for the hour and the ordeal that are now come.

The disciplines of common life are, in great part, exercises in the relations of space, or in the mental grouping of bodies in space; and by such exercises the public mind is, to some extent, prepared for the reception of physical conceptions. Assuming this preparation on your part, the wish gradually grew within me to trace, and to enable you to trace, some of the more occult features and operations of Light and Colour. I wished, if possible, to take you beyond the boundary of mere observation, into a region where things are intellectually discerned, and to show you there the hidden mechanism of optical action.

But how are those hidden things to be revealed? Philosophers may be right in affirming that we cannot transcend experience: we can, at all events, carry it a long way from its origin. We can magnify, diminish, qualify, and combine experiences, so as to render them fit for purposes entirely new. In explaining sensible phenomena, we habitually form mental images of the ultra-sensible. There are Tories even in science who regard Imagination as a faculty to be feared and avoided rather than employed. They have observed its action in weak vessels, and are unduly impressed by its disasters. But they might with equal justice point to exploded boilers as an argument against the use of steam. With accurate experiment and observation to work upon, Imagination becomes the architect of physical theory. Newton's passage from a falling apple to a falling moon was an act of the prepared imagination, without which the "laws of Kepler" could never have been traced to their foundations. Out of the facts of chemistry the constructive imagination of Dalton formed the atomic theory. Davy was richly endowed with the imaginative faculty, while with Faraday its exercise was incessant, preceding, accompanying, and guiding all his experiments. His strength and fertility as a discoverer is to be referred in great part to the stimulus of his imagination. Scientific men fight shy of the word because of its ultra-scientific connotations; but the fact is that without the exercise of this power our knowledge of nature would be a mere tabulation of co-existences and sequences. We should still believe in the succession of day and night, of summer and winter; but the conception of Force would vanish from our universe; causal relations would disappear, and with them that science which is now binding the parts of nature to an organic whole.

I should like to illustrate by a few simple instances the use that scientific men have already made of this power of imagination, and to indicate afterwards some of the further uses that they are likely to make of it. Let us begin with the rudimentary experiences. Observe the falling of heavy rain-drops into a tranquil pond. Each drop as it strikes the water becomes a centre of disturbance, from which a series of ring-ripples expand outwards. Gravity and inertia are the agents by which this wave-motion is produced, and a rough experiment will suffice to show that the rate of propagation does not amount to a foot a second. A series of slight mechanical shocks is experienced by a body plunged in the water, as the wavelets reach it in succession. But a finer motion is at the same time set up and propagated. If the head and ears be immersed in the water, as in an experiment of Franklin's, the *tick* of the drop is heard. Now, this sonorous impulse is propagated, not at the rate of a foot, but at the rate of 4,700 feet a second. In this case it is not the gravity but the *elasticity* of the water that comes into play. Every liquid particle pushed against its neighbour delivers up its motion with extreme rapidity, and the pulse is propagated as a thrill. The incompressibility of water, as illustrated by the famous Florentine experiment, is a measure of its elasticity;

and to the possession of this property, in so high a degree, the rapid transmission of a sound-pulse through water is to be ascribed.

But water, as you know, is not necessary to the conduction of sound; air is its most common vehicle. And you know that when the air possesses the particular density and elasticity corresponding to the temperature of freezing water, the velocity of sound in it is 1,090 feet a second. It is almost exactly one-fourth of the velocity in water; the reason being that, though the greater weight of the water tends to diminish the velocity, the enormous molecular elasticity of the liquid far more than atones for the disadvantage due to weight. By various contrivances we can compel the vibrations of the air to declare themselves; we know the length and frequency of the sonorous waves, and we have also obtained great mastery over the various methods by which the air is thrown into vibration. We know the phenomena and laws of vibrating rods, of organ-pipes, strings, membranes, plates, and bells. We can abolish one sound by another. We know the physical meaning of music and noise, of harmony and discord. In short, as regards sound in general, we have a very clear notion of the external physical processes which correspond to our sensations.

In the phenomena of sound, we travel a very little way from downright sensible experience. Still the imagination is to some extent exercised. The bodily eye, for example, cannot see the condensations and rarefactions of the waves of sound. We construct them in thought, and we believe as firmly in their existence as in that of the air itself. But now our experience is to be carried into a new region, where a new use is to be made of it. Having mastered the cause and mechanism of sound, we desire to know the cause and mechanism of light. We wish to extend our inquiries from the auditory to the optic nerve. There is in the human intellect a power of expansion—I might almost call it a power of creation—which is brought into play by the simple brooding upon facts. The legend of the spirit brooding over chaos may have originated in experience of this power. In the case now before us it has manifested itself by transplanting into space, for the purposes of light, an adequately modified form of the mechanism of sound. We know intimately whereon the velocity of sound depends. When we lessen the density of the aërial medium, and preserve its elasticity constant, we augment the velocity. When we heighten the elasticity and keep the density constant we also augment the velocity. A small density, therefore, and a great elasticity, are the two things necessary to rapid propagation. Now light is known to move with the astounding velocity of 186,000 miles a second. How is such a velocity to be obtained? By boldly diffusing in space a medium of the requisite tenuity and elasticity.

Let us make such a medium our starting-point, and, endowing it with one or two other necessary qualities, let us handle it in accordance with strict mechanical laws. Let us then carry our results from the world of theory into the world of sense, and see whether our deductions do not issue in the very phenomena of light which ordinary knowledge and skilled experiment reveal. If in all the multiplied varieties of these phenomena, including those of the most remote and entangled description, this fundamental conception always brings us face to face with the truth; if no contradiction to our deductions from it be found in external nature, but on all sides agreement and verification; if, moreover, as in the case of Conical Refraction and in other cases, it actually forces upon our attention phenomena which no eye had previously seen, and which no mind had previously imagined—such a conception must, we think, be something more than a mere figment of the scientific fancy. In forming it, that composite and creative power, in which reason and imagination are united, has, we believe, led us into a world not less

real than that of the senses, and of which the world of sense itself is the suggestion and, to a great extent, the outcome.

Far be it from me, however, to wish to fix you immovably in this or in any other theoretic conception. With all our belief of it, it will be well to keep the theory of a luminiferous ether plastic and capable of change. You may, moreover, urge that, although the phenomena occur *as if* the medium existed, the absolute demonstration of its existence is still wanting. Far be it from me to deny to this reasoning such validity as it may fairly claim. Let us endeavour by means of analogy to form a fair estimate of its force. You believe that in society you are surrounded by reasonable beings like yourself. You are, perhaps, as firmly convinced of this as of anything. What is your warrant for this conviction? Simply and solely this: your fellow-creatures behave as if they were reasonable; the hypothesis, for it is nothing more, accounts for the facts. To take an eminent example: you believe that our President is a reasonable being. Why? There is no known method of superposition by which any one of us can apply himself intellectually to any other, so as to demonstrate coincidence as regards the possession of reason, If, therefore, you hold our President to be reasonable, it is because he behaves *as if* he were reasonable. As in the case of the ether, beyond the "*as if*" you cannot go. Nay, I should not wonder if a close comparison of the data on which both inferences rest caused many respectable persons to conclude that the ether had the best of it.

This universal medium, this light-ether as it is called, is the vehicle, not the origin, of wave-motion. It receives and transmits, but it does not create. Whence does it derive the motions it conveys? For the most part from luminous bodies. By the motion of a luminous body I do not mean its sensible motion, such as the flicker of a candle, or the shooting out of red prominences from the limb of the sun. I mean an intestine motion of the atoms or molecules of the luminous body. But here a certain reserve is necessary. Many chemists of the present day refuse to speak of atoms and molecules as real things. Their caution leads them to stop short of the clear, sharp, mechanically intelligible atomic theory enunciated by Dalton, or any form of that theory, and to make the doctrine of "multiple proportions" their intellectual bourne. I respect the caution, though I think it is here misplaced. The chemists who recoil from these notions of atoms and molecules accept, without hesitation, the Undulatory Theory of Light. Like you and me, they one and all believe in an ether and its light-producing waves. Let us consider what this belief involves. Bring your imaginations once more into play, and figure a series of sound-waves passing through air. Follow them up to their origin, and what do you there find? A definite, tangible, vibrating body. It may be the vocal chords of a human being, it may be an organ-pipe, or it may be a stretched string. Follow in the same manner a train of ether-waves to their source, remembering at the same time that your ether is matter, dense, elastic, and capable of motions subject to, and determined by, mechanical laws. What then do you expect to find as the source of a series of ether-waves? Ask your imagination if it will accept a vibrating multiple proportion—a numerical ratio in a state of oscillation? I do not think it will. You cannot crown the edifice with this abstraction. The scientific imagination, which is here authoritative, demands, as the origin and cause of a series of ether-waves, a particle of vibrating matter quite as definite, though it may be excessively minute, as that which gives origin to a musical sound. Such a particle we name an atom or a molecule. I think the intellect, when focussed so as to give definition without penumbral haze, is sure to realise this image at the last.

* * *

With the view of preserving thought

continuous throughout this discourse, and of preventing either failure of knowledge, or of memory from causing any rent in our picture, I here propose to run rapidly over a bit of ground which is probably familiar to most of you, but which I am anxious to make familiar to you all. The waves generated in the ether by the swinging atoms of luminous bodies are of different lengths and amplitudes. The amplitude is the width of swing of the individual particles of the waves. In water-waves it is the vertical height of the crest above the trough, while the length of the wave is the horizontal distance between two consecutive crests. The aggregate of waves emitted by the sun may be broadly divided into two classes: the one class competent, the other incompetent, to excite vision. But the light-producing waves differ markedly among themselves in size, form, and force. The length of the largest of these waves is about twice that of the smallest, but the amplitude of the largest is probably a hundred times that of the smallest. Now the force or energy of the wave, which, expressed with reference to sensation, means the intensity of the light, is proportional to the square of the amplitude. Hence the amplitude being one-hundred-fold, the energy of the largest light-giving waves would be ten-thousand-fold that of the smallest. This is not improbable. I use these figures not with a view to numerical accuracy, but to give you definite ideas of the differences that probably exist among the light-giving waves. And if we take the whole range of solar radiation into account—its non-visual as well as its visual waves—I think it probable that the force, or energy, of the largest wave is more than a million times that of the smallest.

Turned into their equivalents of sensation, the different light-waves produce different colours. Red, for example, is produced by the largest waves, violet by the smallest, while green is produced by a wave of intermediate length and amplitude. On entering from air into a more highly refracting substance, such as glass or water, or the sulphide of carbon, all the waves are retarded, but the smallest ones most. This furnishes a means of separating the different classes of waves from each other; in other words, of analysing the light. Sent through a refracting prism, the waves of the sun are turned aside in different degrees from their direct course, the red least, the violet most. They are virtually pulled asunder, and they paint upon a white screen placed to receive them "the solar spectrum." Strictly speaking, the spectrum embraces an infinity of colours; but the limits of language, and of our powers of distinction, cause it to be divided into seven segments: red, orange, yellow, green, blue, indigo, violet. These are the seven primary or prismatic colours.

Separately, or mixed in various proportions, the solar waves yield all the colours observed in nature and employed in art. Collectively, they give us the impression of whiteness. Pure unsifted solar light is white; and, if all the wave-constituents of such light be reduced in the same proportion, the light, though diminished in intensity, will still be white. The whiteness of snow with the sun shining upon it is barely tolerable to the eye. The same snow under an overcast firmament is still white. Such a firmament enfeebles the light by reflecting it upwards: and when we stand above a cloud-field—on an Alpine summit, for instance, or on the top of Snowdon—and see, in the proper direction, the sun shining on the clouds below us, they appear dazzlingly white. Ordinary clouds, in fact, divide the solar light impinging on them into two parts—a reflected part and a transmitted part—in each of which the proportions of wave-motion which produce the impression of whiteness are sensibly preserved.

It will be understood that the condition of whiteness would fail if all the waves were diminished *equally*, or by the same absolute quantity. They must be reduced *proportionately*, instead of equally. If by the act of reflection the

waves of red light are split into exact halves, then, to preserve the light white, the waves of yellow, orange, green, and blue must also be split into exact halves. In short, the reduction must take place, not by absolutely equal quantities, but by equal fractional parts. In white light the preponderance, as regards energy, of the larger over the smaller waves must always be immense. Were the case otherwise, the visual correlative, *blue*, of the smaller waves would have the upper hand in our sensations.

Not only are the waves of ether reflected by clouds, by solids, and by liquids, but when they pass from light air to dense, or from dense air to light, a portion of the wave-motion is always reflected. Now, our atmosphere changes continually in density from top to bottom. It will help our conception if we regard it as made up of a series of thin concentric layers, or shells of air, each shell being of the same density throughout, a small and sudden change of density occurring in passing from shell to shell. Light would be reflected at the limiting surfaces of all these shells, and their action would be practically the same as that of the real atmosphere. And now I would ask your imagination to picture this act of reflection. What must become of the reflected light? The atmospheric layers turn their convex surfaces towards the sun; they are so many convex mirrors of feeble power; and you will immediately perceive that the light regularly reflected from these surfaces cannot reach the earth at all, but is dispersed in space. Light thus reflected cannot, therefore, be the light of the sky.

But, though the sun's light is not reflected in this fashion from the aërial layers to the earth, there is indubitable evidence to show that the light of our firmament is scattered light. Proofs of the most cogent description could be here adduced; but we need only consider that we receive light at the same time from all parts of the hemisphere of heaven. The light of the firmament comes to us across the direction of the solar rays, and even against the direction of the solar rays; and this lateral and opposing rush of wave-motion can only be due to the rebound of the waves from the air itself, or from something suspended in the air. It is also evident that, unlike the action of clouds, the solar light is not reflected by the sky in the proportions which produce white. The sky is blue, which indicates an excess of the shorter waves. In accounting for the colour of the sky, the first question suggested by analogy would undoubtedly be, Is not the air blue? The blueness of the air has, in fact, been given as a solution of the blueness of the sky. But how, if the air be blue, can the light of sunrise and sunset, which travels through vast distances of air, be yellow, orange, or even red? The passage of white solar light through a blue medium could by no possibility redden the light. The hypothesis of a blue air is therefore untenable. In fact, the agent, whatever it is, which sends us the light of the sky, exercises in so doing a dichroitic action. The light reflected is blue, the light transmitted is orange or red. A marked distinction is thus exhibited between the matter of the sky and that of an ordinary cloud, which exercises no such dichroitic action.

By the scientific use of the imagination we may hope to penetrate this mystery. The cloud takes no note of size on the part of the waves of ether, but reflects them all alike. It exercises no selective action. Now, the cause of this may be that the cloud particles are so large, in comparison with the waves of ether, as to reflect them all indifferently. A broad cliff reflects an Atlantic roller as easily as a ripple produced by a sea-bird's wing; and in the presence of large reflecting surfaces the existing differences of magnitude among the waves of ether may disappear. But supposing the reflecting particles, instead of being very large, to be very small in comparison with the size of the waves. In this case, instead of the whole wave being fronted and thrown back, a small portion only is

shivered off. The great mass of the wave passes over such a particle without reflection. Scatter, then, a handful of such minute foreign particles in our atmosphere, and set imagination to watch their action upon the solar waves. Waves of all sizes impinge upon the particles, and you see at every collision a portion of the impinging wave struck off; all the waves of the spectrum, from the extreme red to the extreme violet, being thus acted upon.

Remembering that the red waves stand to the blue much in the relation of billows to ripples, we have to consider whether those extremely small particles are competent to scatter all the waves in the same proportion. If they be not—and a little reflection will make it clear that they are not—the production of colour must be an incident of the scattering. Largeness is a thing of relation; and the smaller the wave, the greater is the relative size of any particle on which the wave impinges, and the greater also the ratio of the portion scattered to the total wave. A pebble, placed in the way of the ring-ripples produced by heavy rain-drops on a tranquil pond, will scatter a large fraction of each ripple, while the fractional part of a larger wave thrown back by the same pebble might be infinitesimal. Now we have already made it clear to our minds that, to preserve the solar light white, its constituent proportions must not be altered; but in the act of division performed by these very small particles the proportions *are* altered; an undue fraction of the smaller waves is scattered by the particles, and, as a consequence, in the scattered light blue will be the predominant colour. The other colours of the spectrum must, to some extent, be associated with the blue. They are not absent, but deficient. We ought, in fact, to have them all, but in diminishing proportions, from the violet to the red.

We have here presented a case to the imagination, and, assuming the undulatory theory to be a reality, we have, I think, fairly reasoned our way to the conclusion, that were particles, small in comparison to the sizes of the ether waves, sown in our atmosphere, the light scattered by those particles would be exactly such as we observe in our azure skies. When this light is analysed, all the colours of the spectrum are found, and they are found in the proportions indicated by our conclusion. Blue is not the sole, but it is the predominant colour.

Let us now turn our attention to the light which passes unscattered among the particles. How must it be finally affected? By its successive collisions with the particles the white light is more and more robbed of its shorter waves; it therefore loses more and more of its due proportion of blue. The result may be anticipated. The transmitted light, where short distances are involved, will appear yellowish. But as the sun sinks towards the horizon the atmospheric distances increase, and consequently the number of the scattering particles. They abstract in succession the violet, the indigo, the blue, and even disturb the proportions of green. The transmitted light under such circumstances must pass from yellow through orange to red. This also is exactly what we find in nature. Thus, while the reflected light gives us at noon the deep azure of the Alpine skies, the transmitted light gives us at sunset the warm crimson of the Alpine snows. The phenomena certainly occur *as if* our atmosphere were a medium rendered slightly turbid by the mechanical suspension of exceedingly small foreign particles.

Here, as before, we encounter our sceptical "*as if*." It is one of the parasites of science, ever at hand, and ready to plant itself and sprout, if it can, on the weak points of our philosophy. But a strong constitution defies the parasite, and in our case, as we question the phenomena, probability grows like growing health, until in the end the malady of doubt is completely extirpated. The first question that naturally arises is this: Can small particles be really proved

to act in the manner indicated? No doubt of it. Each one of you can submit the question to an experimental test. Water will not dissolve resin, but spirit will dissolve it; and when spirit holding resin in solution is dropped into water, the resin immediately separates in solid particles, which render the water milky. The coarseness of this precipitate depends on the quantity of the dissolved resin. You can cause it to separate either in thick clots or in exceedingly fine particles. Professor Brücke has given us the proportions which produce particles particularly suited to our present purpose. One gramme of clean mastic is dissolved in eighty-seven grammes of absolute alcohol, and the transparent solution is allowed to drop into a beaker containing clear water, kept briskly stirred. An exceedingly fine precipitate is thus formed, which declares its presence by its action upon light. Placing a dark surface behind the beaker, and permitting the light to fall into it from the top or front, the medium is seen to be distinctly blue. It is not perhaps so perfect a blue as may be seen on exceptional days among the Alps, but it is a very fair sky-blue. A trace of soap in water gives a tint of blue. London, and I fear Liverpool, milk makes an approximation to the same colour, through the operation of the same cause; and Helmholtz has irreverently disclosed the fact that the deepest blue eye is simply a turbid medium.

The action of turbid media upon light was illustrated by Goethe, who, though unacquainted with the undulatory theory, was led by his experiments to regard the firmament as an illuminated turbid medium, with the darkness of space behind it. He describes glasses showing a bright yellow by transmitted, and a beautiful blue by reflected, light. Professor Stokes, who was probably the first to discern the real nature of the action of small particles on the waves of ether,[1] describes a glass of a similar kind.[1] Capital specimens of such glass are to be found at Salviati's, in St. James's Street. What artists call "chill" is no doubt an effect of this description. Through the action of minute particles, the browns of a picture often present the appearance of the bloom of a plum. By rubbing the varnish with a silk handkerchief optical continuity is established and the chill disappears. Some years ago I witnessed Mr. Hirst experimenting at Zermatt on the turbid water of the Visp. When kept still for a day or so, the grosser matter sank, but the finer particles remained suspended, and gave a distinctly blue tinge to the water. The blueness of certain Alpine lakes has been shown to be in part due to this cause. Professor Roscoe has noticed several striking cases of a similar kind. In a very remarkable paper the late Principal Forbes showed that steam issuing from the safety-valve of a locomotive, when favourably observed, exhibits at a certain stage of its condensation the colours of the sky. It is blue by reflected light, and orange or red by transmitted light. The same effect, as pointed out by Goethe, is to some extent exhibited by peat-smoke. More than ten years ago, I amused myself by observing, on a calm day at Killarney, the straight smoke-columns rising from the cabin-chimneys. It was easy to project the lower portion of a column against a dark pine, and its upper portion against a bright cloud. The smoke in the former case was blue, being seen mainly by reflected light; in the latter case it was reddish, being seen mainly by transmitted light. Such smoke was not in

[1] This is inferred from conversation. I am not aware that Professor Stokes has published anything upon the subject.

[1] This glass, by reflected light, had a colour "strongly resembling that of a decoction of horse-chesnut bark." Curiously enough, Goethe refers to this very decoction: "Man nehme einen Streifen frischer Rinde von der Rosskastanie, man stecke denselben in ein Glas Wasser, und in der kürzesten Zeit werden wir das vollkommenste Himmelblau entstehen sehen."—Goethe's *Werke*, B. xxix., p. 24.

exactly the condition to give us the glow of the Alps, but it was a step in this direction. Brücke's fine precipitate, above referred to, looks yellowish by transmitted light; but, by duly strengthening the precipitate, you may render the white light of noon as ruby-coloured as the sun, when seen through Liverpool smoke or upon Alpine horizons. I do not, however, point to the gross smoke arising from coal as an illustration of the action of small particles, because such smoke soon absorbs and destroys the waves of blue, instead of sending them to the eyes of the observer.

These multifarious facts, and numberless others which cannot now be referred to, are explained by reference to the single principle, that, where the scattering particles are small in comparison to the ethereal waves, we have in the reflected light a greater proportion of the smaller waves, and in the transmitted light a greater proportion of the larger waves, than existed in the original white light. The consequence, as regards sensation, is that in the one case blue is predominant, and in the other orange or red. Our best microscopes can readily reveal objects not more than $\frac{1}{5000}$th of an inch in diameter. This is less than the length of a wave of red light. Indeed, a first-rate microscope would enable us to discern objects not exceeding in diameter the length of the smallest waves of the visible spectrum.[1] By the microscope, therefore, we can test our particles. If they be as large as the light-waves, they will infallibly be seen; and if they be not so seen, it is because they are smaller. Some months ago I placed in the hands of our President a liquid containing Brücke's precipitate. The liquid was milky blue, and Mr. Huxley applied to it his highest microscopic power. He satisfied me that, had particles of even $\frac{1}{100000}$th of an inch in diameter existed in the liquid, they could not have escaped detection. But no particles were seen. Under the microscope the turbid liquid was not to be distinguished from distilled water.[1]

But we have it in our power to imitate, far more closely than we have hitherto done, the natural conditions of this problem. We can generate, in air, artificial skies, and prove their perfect identity with the natural one, as regards the exhibition of a number of wholly unexpected phenomena. By a continuous process of growth, moreover, we are able to connect sky-matter, if I may use the term, with molecular matter on the one side, and with molar matter, or matter in sensible masses, on the other. In illustration of this, I will take an experiment suggested by some of my own researches, and described by M. Morren of Marseilles at the Exeter meeting of the British Association. Sulphur and oxygen combine to form sulphurous acid gas, two atoms of oxygen and one of sulphur constituting the molecule of sulphurous acid. It has been recently shown that waves of ether issuing from a strong source, such as the sun or the electric light, are competent to shake asunder the atoms of gaseous molecules.[2] A chemist would call this "decomposition" by light; but it behoves us, who are examining the power and function of the imagination, to keep constantly before us the physical images which underlie our terms. Therefore I say, sharply and definitely, that the components of the molecules of sulphurous acid are shaken asunder by the ether-waves. Enclosing sulphurous acid in a suitable vessel, placing it in a dark room, and sending through it a powerful beam of light, we at first see nothing: the vessel containing the gas seems as empty as a vacuum. Soon,

[1] Dallinger and Drysdale have recently measured cilia $\frac{1}{200000}$th of an inch in diameter. 1878.

[1] Like Dr. Burdon Sanderson's "pyrogen," the particles of mastic passed, without sensible hindrance, through filtering-paper. By such filtering no freedom from suspended particles is secured. The application of a condensed beam to the filtrate renders this at once evident.

[2] See article on "New Chemical Reactions Produced by Light," *Fragments of Science*, vol. i.

however, along the track of the beam a beautiful sky-blue colour is observed, which is due to light scattered by the liberated particles of sulphur. For a time the blue grows more intense; it then becomes whitish, and ends in a more or less perfect white. When the action is continued long enough, the tube is filled with a dense cloud of sulphur particles, which by the application of proper means may be rendered individually visible.[1]

Here, then, our ether-waves untie the bond of chemical affinity, and liberate a body—sulphur—which at ordinary temperatures is a solid, and which therefore soon becomes an object of the senses. We have first of all the free atoms of sulphur, which are incompetent to stir the retina sensibly with scattered light. But these atoms gradually coalesce and form *particles*, which grow larger by continual accretion, until after a minute or two they appear as sky-matter. In this condition they are individually invisible; but collectively they send an amount of wave-motion to the retina, sufficient to produce the firmamental blue. The particles continue, or may be caused to continue, in this condition for a considerable time, during which no microscope can cope with them. But they grow slowly larger, and pass by insensible gradations into the state of *cloud*, when they can no longer elude the armed eye. Thus, without solution of continuity, we start with matter in the atom, and end with matter in the mass; sky-matter being the middle term of the series of transformations.

Instead of sulphurous acid, we might choose a dozen other substances, and produce the same effect with all of them. In the case of some—probably in the case of all—it is possible to preserve matter in the firmamental condition for fifteen or twenty minutes under the continual operation of the light. During these fifteen or twenty minutes the particles constantly grow larger, without ever exceeding the size requisite to the production of the celestial blue. Now, when two vessels are placed before us, each containing sky-matter, it is possible to state with great distinctness which vessel contains the largest particles. The eye is very sensitive to differences of light, when, as in our experiments, it is placed in comparative darkness, and the wave-motion thrown against the retina is small. The larger particles declare themselves by the greater whiteness of their scattered light. Call now to mind the observation, or effort at observation, made by our President, when he failed to distinguish the particles of mastic in Brücke's medium, and when you have done this, please follow me. A beam of light is permitted to act upon a certain vapour. In two minutes the azure appears, but at the end of fifteen minutes it has not ceased to be azure. After fifteen minutes its colour, and some other phenomena, pronounce it to be a blue of distinctly smaller particles than those sought for in vain by Mr. Huxley. These particles, as already stated, must have been less than $\frac{1}{100000}$th of an inch in diameter. And now I want you to consider the following question: Here are particles which have been growing continually for fifteen minutes, and at the end of that time are demonstrably smaller than those which defied the microscope of Mr. Huxley—*What must have been the size of these particles at the beginning of their growth?* What notion can you form of the magnitude of such particles? The distances of stellar space give us simply a bewildering sense of vastness, without leaving any distinct impression on the mind; and the magnitudes with which we have here to do, bewilder us equally in the opposite direction. We are dealing with infinitesimals, compared with which the test objects of the microscope are literally immense.

[1] M. Morren was mistaken in supposing that a modicum of sulphurous acid, in the drying tubes, had any share in the production of the "actinic clouds" described by me. A beautiful case of molecular instability in the presence of light is furnished by peroxide of chlorine, as proved by Professor Dewar. 1878.

Small in mass, the vastness in point of number of the particles of our sky may be inferred from the continuity of its light. It is not in broken patches, nor at scattered points, that the heavenly azure is revealed. To the observer on the summit of Mont Blanc, the blue is as uniform and coherent as if it formed the surface of the most close-grained solid. A marble dome would not exhibit a stricter continuity. And Mr. Glaisher will inform you that, if our hypothetical shell were lifted to twice the height of Mont Blanc above the earth's surface, we should still have the azure overhead. By day this light quenches the stars; even by moonlight it is able to exclude from vision all stars between the fifth and the eleventh magnitude. It may be likened to a noise, and the feebler stellar radiance to a whisper drowned by the noise.

What is the nature of the particles which shed this light? The celebrated De la Rive ascribes the haze of the Alps in fine weather to floating organic germs. Now the possible existence of germs in such profusion has been held up as an absurdity. It has been affirmed that they would darken the air, and on the assumed impossibility of their existence in the requisite numbers, without invasion of the solar light, an apparently powerful argument has been based by believers in spontaneous generation. Similar arguments have been used by the opponents of the germ theory of epidemic disease, who have triumphantly challenged an appeal to the microscope and the chemist's balance to decide the question. Such arguments, however, are founded on a defective acquaintance with the powers and properties of matter. Without committing myself in the least to De la Rive's notion, to the doctrine of spontaneous generation, or to the germ theory of disease, I would simply draw attention to the demonstrable fact, that in the atmosphere we have particles which defy both the microscope and the balance, which do not darken the air, and which exist, nevertheless, in multitudes sufficient to reduce to insignificance the Israelitish hyperbole regarding the sands upon the sea-shore.

The varying judgments of men on these and other questions may perhaps be, to some extent, accounted for by that doctrine of Relativity which plays so important a part in philosophy. This doctrine affirms that the impressions made upon us by any circumstance, or combination of circumstances, depend upon our previous state. Two travellers upon the same height, the one having ascended to it from the plain, the other having descended to it from a higher elevation, will be differently affected by the scene around them. To the one nature is expanding, to the other it is contracting; and impressions which have two such different antecedent states are sure to differ. In our scientific judgments the law of relativity may also play an important part. To two men, one educated in the school of the senses, having mainly occupied himself with observation; the other educated in the school of imagination as well, and exercised in the conceptions of atoms and molecules to which we have so frequently referred, a bit of matter, say $\frac{1}{5000}$th of an inch in diameter, will present itself differently. The one descends to it from his molar heights, the other climbs to it from his molecular lowlands. To the one it appears small, to the other large. So, also, as regards the appreciation of the most minute forms of life revealed by the microscope. To one of the men these naturally appear conterminous with the ultimate particles of matter; there is but a step from the atom to the organism. The other discerns numberless organic gradations between both. Compared with his atoms, the smallest vibrios and bacteria of the microscopic field are as behemoth and leviathan. The law of relativity may to some extent explain the different attitudes of two such persons with regard to the question of spontaneous generation. An amount of evidence which satisfies the one entirely fails to satisfy the other;

and while to the one the last bold defence and startling expansion of the doctrine by Dr. Bastian will appear perfectly conclusive, to the other it will present itself as merely imposing a labour of demolition on subsequent investigators.[1]

Let me say here that many of our physiological observers appear to form a very inadequate estimate of the distance which separates the microscopic from the molecular limit, and that, as a consequence, they sometimes employ a phraseology calculated to mislead. When, for example, the contents of a cell are described as perfectly homogeneous or as absolutely structureless, because the microscope fails to discover any structure; or when two structures are pronounced to be without difference, because the microscope can discover none, then, I think, the microscope begins to play a mischievous part. A little consideration will make it plain that the microscope can have no voice in the question of germ structure. Distilled water is more perfectly homogeneous than any possible organic germ. What is it that causes the liquid to cease contracting at 39° Fahr., and to expand until it freezes? We have here a structural process of which the microscope can take no note, nor is it likely to do so by any conceivable extension of its powers. Place distilled water in the field of an electro-magnet, and bring a microscope to bear upon it. Will any change be observed when the magnet is excited? Absolutely none; and, still, profound and complex changes have occurred. First of all, the particles of water have been rendered diamagnetically polar; and secondly, in virtue of the structure impressed upon it by the magnetic whirl of its molecules, the liquid twists a ray of light in a fashion perfectly determinate both as to quantity and direction.

Have the diamond, the amethyst, and the countless other crystals formed in the laboratories of nature and of man no structure? Assuredly they have; but what can the microscope make of it? Nothing. It cannot be too distinctly borne in mind that between the microscopic limit and the true molecular limit there is room for infinite permutations and combinations. It is in this region that the poles of the atoms are arranged, that tendency is given to their powers; so that when these poles and powers have free action, proper stimulus, and a suitable environment, they determine, first the germ, and afterwards the complete organism. This first marshalling of the atoms, on which all subsequent action depends, baffles a keener power than that of the microscope. When duly pondered, the complexity of the problem raises the doubt, not of the power of our instrument, for that is *nil*, but whether we ourselves possess the intellectual elements which will ever enable us to grapple with the ultimate structural energies of nature.[1]

In more senses than one Mr. Darwin has drawn heavily upon the scientific tolerance of his age. He has drawn heavily upon time in his development of species, and he has drawn adventurously upon matter in his theory of pangenesis. According to this theory, a germ, already microscopic, is a world of minor germs. Not only is the organism as a whole wrapped up in the germ, but every organ of the organism has there its special seed. This, I say, is an adventurous draft on the power of matter to divide itself and distribute its forces. But, unless we are perfectly sure that he is overstepping the bounds of reason, that he is unwittingly

[1] When these words were uttered I did not imagine that the chief labour of demolition would fall upon myself, 1878.

[1] "In using the expression, 'one sort of living substance,' I must guard against being supposed to mean that any kind of living protoplasm is homogeneous. Hyaline though it may appear, we are not at present able to assign any limit to its complexity of structure."—Burdon Sanderson, in the *British Medical Journal*, January 16th, 1875. We have here scientific insight, and its correlative caution. In fact, Dr. Sanderson's important researches are a continued illustration of the position laid down above.

sinning against observed fact or demonstrated law—for a mind like that of Darwin can never sin wittingly against either fact or law—we ought, I think, to be cautious in limiting his intellectual horizon. If there be the least doubt in the matter, it ought to be given in favour of the freedom of such a mind. To it a vast possibility is in itself a dynamic power, though the possibility may never be drawn upon. It gives me pleasure to think that the facts and reasonings of this discourse tend rather towards the justification of Mr. Darwin than towards his condemnation; for they seem to show the perfect competence of matter and force, as regards divisibility and distribution, to bear the heaviest strain that he has hitherto imposed upon them.

In the case of Mr. Darwin, observation, imagination, and reason combined have run back with wonderful sagacity and success over a certain length of the line of biological succession. Guided by analogy, in his *Origin of Species* he placed at the root of life a primordial germ, from which he conceived the amazing variety of the organisms now upon the earth's surface might be deduced. If this hypothesis were even true, it would not be final. The human mind would infallibly look behind the germ, and, however hopeless the attempt, would inquire into the history of its genesis. In this dim twilight of conjecture the searcher welcomes every gleam, and seeks to augment his light by indirect incidences. He studies the methods of nature in the ages and the worlds within his reach, in order to shape the course of speculation in antecedent ages and worlds. And though the certainty possessed by experimental inquiry is here shut out, we are not left entirely without guidance. From the examination of the solar system, Kant and Laplace came to the conclusion that its various bodies once formed parts of the same undislocated mass; that matter in a nebulous form preceded matter in its present form; that, as the ages rolled away, heat was wasted, condensation followed, planets were detached; and that finally the chief portion of the hot cloud reached, by self-compression, the magnitude and density of our sun. The earth itself offers evidence of a fiery origin; and in our day the hypothesis of Kant and Laplace receives the independent countenance of spectrum analysis, which proves the same substances to be common to the earth and sun.

Accepting some such view of the construction of our system as probable, a desire immediately arises to connect the present life of our planet with the past. We wish to know something of our remotest ancestry. On its first detachment from the central mass, life, as we understand it, could not have been present on the earth. How, then, did it come there? The thing to be encouraged here is a reverent freedom—a freedom preceded by the hard discipline which checks licentiousness in speculation—while the thing to be repressed, both in science and out of it, is dogmatism. And here I am in the hands of the meeting—willing to end, but ready to go on. I have no right to intrude upon you, unasked, the unformed notions which are floating like clouds, or gathering to more solid consistency, in the modern speculative scientific mind. But if you wish me to speak plainly, honestly, and undisputatiously, I am willing to do so. On the present occasion—

"You are ordained to call, and I to come."

Well, your answer is given, and I obey your call.

Two or three years ago, in an ancient London College, I listened to a discussion at the end of a lecture by a very remarkable man. Three or four hundred clergymen were present at the lecture. The orator began with the civilisation of Egypt in the time of Joseph; pointing out the very perfect organisation of the kingdom, and the possession of chariots, in one of which Joseph rode, as proving a long antecedent period of civilisation. He then passed on to the mud of the Nile, its rate of augmentation, its present thickness, and the remains of human

handiwork found therein: thence to the rocks which bound the Nile valley, and which teem with organic remains. Thus in his own clear way he caused the idea of the world's age to expand itself indefinitely before the minds of his audience, and he contrasted this with the age usually assigned to the world. During his discourse he seemed to be swimming against a stream; he manifestly thought that he was opposing a general conviction. He expected resistance in the subsequent discussion; so did I. But it was all a mistake; there was no adverse current, no opposing conviction, no resistance; merely here and there a half-humorous but unsuccessful attempt to entangle him in his talk. The meeting agreed with all that had been said regarding the antiquity of the earth and of its life. They had, indeed, known it all long ago, and they rallied the lecturer for coming among them with so stale a story. It was quite plain that this large body of clergymen, who were, I should say, to be ranked among the finest samples of their class, had entirely given up the ancient landmarks, and transported the conception of life's origin to an indefinitely distant past.

This leads us to the gist of our present inquiry, which is this: Does life belong to what we call matter, or is it an independent principle inserted into matter at some suitable epoch—say when the physical conditions became such as to permit of the development of life? Let us put the question with the reverence due to a faith and culture in which we all were cradled, and which are the undeniable historic antecedents of our present enlightenment. I say, let us put the question reverently, but let us also put it clearly and definitely. There are the strongest grounds for believing that during a certain period of its history the earth was not, nor was it fit to be, the theatre of life. Whether this was ever a nebulous period, or merely a molten period, does not signify much; and if we revert to the nebulous condition, it is because the probabilities are really on its side. Our question is this: Did creative energy pause until the nebulous matter had condensed, until the earth had been detached, until the solar fire had so far withdrawn from the earth's vicinity as to permit a crust to gather round the planet? Did it wait until the air was isolated; until the seas were formed; until evaporation, condensation, and the descent of rain had begun; until the eroding forces of the atmosphere had weathered and decomposed the molten rocks so as to form soils; until the sun's rays had become so tempered by distance, and by waste, as to be chemically fit for the decomposition necessary to vegetable life? Having waited through these æons until the proper conditions had set in, did it send the fiat forth, "Let there be Life!"? These questions define a hypothesis not without its difficulties, but the dignity of which in relation to the world's knowledge was demonstrated by the nobleness of the men whom it sustained.

Modern scientific thought is called upon to decide between this hypothesis and another; and public thought generally will afterwards be called upon to do the same. But, however the convictions of individuals here and there may be influenced, the process must be slow and secular which commends the hypothesis of Natural Evolution to the public mind. For what are the core and essence of this hypothesis? Strip it naked, and you stand face to face with the notion that not alone the more ignoble forms of animalcular or animal life, not alone the nobler forms of the horse and lion, not alone the exquisite and wonderful mechanism of the human body, but that the human mind itself—emotion, intellect, will, and all their phenomena—were once latent in a fiery cloud. Surely the mere statement of such a notion is more than a refutation. But the hypothesis would probably go even farther than this. Many who hold it would probably assent to the position that, at the present moment, all our philosophy, all our poetry, all our science, and all our art—

Plato, Shakespeare, Newton, and Raphael—are potential in the fires of the sun. We long to learn something of our origin. If the Evolution hypothesis be correct, even this unsatisfied yearning must have come to us across the ages which separate the primeval mist from the consciousness of to-day. I do not think that any holder of the Evolution hypothesis would say that I overstate or overstrain it in any way. I merely strip it of all vagueness, and bring before you, unclothed and unvarnished, the notions by which it must stand or fall.

Surely these notions represent an absurdity too monstrous to be entertained by any sane mind. But why are such notions absurd, and why should sanity reject them? The law of Relativity, of which we have previously spoken, may find its application here. These Evolution notions are absurd, monstrous, and fit only for the intellectual gibbet, in relation to the ideas concerning matter which were drilled into us when young. Spirit and matter have ever been presented to us in the rudest contrast, the one as all-noble, the other as all-vile. But is this correct? Upon the answer to this question all depends. Supposing that, instead of having the foregoing antithesis of spirit and matter presented to our youthful minds, we had been taught to regard them as equally worthy, and equally wonderful; to consider them, in fact, as two opposite faces of the self-same mystery. Supposing that in youth we had been impregnated with the notion of the poet Goethe, instead of the notion of the poet Young, and taught to look upon matter, not as "brute matter," but as the "living garment of God"; do you not think that under these altered circumstances the law of Relativity might have had an outcome different from its present one? Is it not probable that our repugnance to the idea of primeval union between spirit and matter might be considerably abated? Without this total revolution of the notions now prevalent, the Evolution hypothesis must stand condemned; but in many profoundly thoughtful minds such a revolution has already taken place. They degrade neither member of the mysterious duality referred to; but they exalt one of them from its abasement, and repeal the divorce hitherto existing between them. In substance, if not in words, their position as regards the relation of spirit and matter is: "What God hath joined together, let not man put asunder."

You have been thus led to the outer rim of speculative science, for beyond the nebulæ scientific thought has never hitherto ventured. I have tried to state that which I considered ought, in fairness, to be outspoken. I neither think this Evolution hypothesis is to be flouted away contemptuously, nor that it ought to be denounced as wicked. It is to be brought before the bar of disciplined reason, and there justified or condemned. Let us hearken to those who wisely support it, and to those who wisely oppose it; and let us tolerate those, whose name is legion, who try foolishly to do either of these things. The only thing out of place in the discussion is dogmatism on either side. Fear not the Evolution hypothesis. Steady yourselves, in its presence, upon that faith in the ultimate triumph of truth which was expressed by old Gamaliel when he said: "If it be of God, ye cannot overthrow it; if it be of man, it will come to nought." Under the fierce light of scientific inquiry, it is sure to be dissipated if it possess not a core of truth. Trust me, its existence as a hypothesis is quite compatible with the simultaneous existence of all those virtues to which the term "Christian" has been applied. It does not solve—it does not profess to solve—the ultimate mystery of this universe. It leaves, in fact, that mystery untouched. For, granting the nebula and its potential life, the question, whence they came, would still remain to baffle and bewilder us. At bottom, the hypothesis does nothing more than "transport the conception of life's origin to an indefinitely distant past."

Those who hold the doctrine of Evolution are by no means ignorant of the uncertainty of their data, and they only yield to it a provisional assent. They regard the nebular hypothesis as probable, and, in the utter absence of any evidence to prove the act illegal, they extend the method of nature from the present into the past. Here the observed uniformity of nature is their only guide. Within the long range of physical inquiry they have never discerned in nature the insertion of caprice. Throughout this range the laws of physical and intellectual continuity have run side by side. Having thus determined the elements of their curve in a world of observation and experiment, they prolong that curve into an antecedent world, and accept as probable the unbroken sequence of development from the nebula to the present time. You never hear the really philosophical defenders of the doctrine of Uniformity speaking of *impossibilities* in nature. They never say, what they are constantly charged with saying, that it is impossible for the Builder of the universe to alter His work. Their business is not with the possible, but the actual—not with a world which *might* be, but with a world that *is*. This they explore with a courage not unmixed with reverence, and according to methods which, like the quality of a tree, are tested by their fruits. They have but one desire—to know the truth. They have but one fear—to believe a lie. And if they know the strength of science, and rely upon it with unswerving trust, they also know the limits beyond which science ceases to be strong. They best know that questions offer themselves to thought which science, as now prosecuted, has not even the tendency to solve. They have as little fellowship with the atheist who says there is no God as with the theist who professes to know the mind of God. "Two things," said Immanuel Kant, "fill me with awe: the starry heavens, and the sense of moral responsibility in man." And in his hours of health and strength and sanity, when the stroke of action has ceased, and the pause of reflection has set in, the scientific investigator finds himself overshadowed by the same awe. Breaking contact with the hampering details of earth, it associates him with a Power which gives fulness and tone to his existence, but which he can neither analyse nor comprehend.

SCIENCE AND MAN[1]

A MAGNET attracts iron; but when we analyse the effect we learn that the metal is not only attracted but repelled, the final approach to the magnet being due to the difference of two unequal and opposing forces. Social progress is for the most part typified by this duplex or polar action. As a general rule, every advance is balanced by a partial retreat, every amelioration is associated more or less with deterioration. No great mechanical improvement, for example, is introduced for the benefit of society at large that does not bear hardly upon individuals. Science, like other things, is subject to the operation of this polar law, what is good for it under one aspect being bad for it under another.

[1] Presidential Address, delivered before the Birmingham and Midland Institute, October 1st, 1877; with additions.

Science demands above all things personal concentration. Its home is the study of the mathematician, the quiet laboratory of the experimenter, and the cabinet of the meditative observer of nature. Different atmospheres are required by the man of science, as such, and the man of action. Thus the facilities of social and international intercourse, the railway, the telegraph, and the post-office, which are such undoubted boons to the man of action, re-act, to some extent injuriously, on the man of science. Their tendency is to break up that concentrativeness which, as I have said, is an absolute necessity to the scientific investigator.

The men who have most profoundly influenced the world from the scientific side have habitually sought isolation. Faraday, at a certain period of his career, formally renounced dining out. Darwin lives apart from the bustle of the world in his quiet home in Kent. Mayer and Joule dealt in unobtrusive retirement with the weightiest scientific questions. There is, however, one motive power in the world which no man, be he a scientific student or otherwise, can afford to treat with indifference; and that is, the cultivation of right relations with his fellow-men—the performance of his duty, not as an isolated individual, but as a member of society. It is duty in this aspect, overcoming alike the sense of possible danger and the desire for repose, that has placed me in your presence here to-night.

To look at his picture as a whole, a painter requires distance; and to judge of the total scientific achievement of any age, the standpoint of a succeeding age is desirable. We may, however, transport ourselves in idea into the future, and thus survey with more or less completeness the science of our time. We sometimes hear it decried, and contrasted to its disadvantage with the science of other times. I do not think that this will be the verdict of posterity. I think, on the contrary, that posterity will acknowledge that in the history of science no higher samples of intellectual conquest are recorded than those which this age has made its own. One of the most salient of these I propose, with your permission, to make the subject of our consideration during the coming hour.

It is now generally admitted that the man of to-day is the child and product of incalculable antecedent time. His physical and intellectual textures have been woven for him during his passage through phases of history and forms of existence which lead the mind back to an abysmal past. One of the qualities which he has derived from that past is the yearning to let in the light of principles on the otherwise bewildering flux of phenomena. He has been described by the German Lichtenberg as "das rastlose Ursachenthier"—the restless cause-seeking animal—in whom facts excite a kind of hunger to know the sources from which they spring. Never, I venture to say, in the history of the world has this longing been more liberally responded to, both among men of science and the general public, than during the last thirty or forty years. I say "the general public," because it is a feature of our time that the man of science no longer limits his labours to the society of his colleagues and his peers, but shares, as far as it is possible to share, with the world at large the fruits of inquiry.

The celebrated Robert Boyle regarded the universe as a machine; Mr. Carlyle prefers regarding it as a tree. He loves the image of the umbrageous Igdrasil better than that of the Strasburg clock. A machine may be defined as an organism with life and direction outside; a tree may be defined as an organism with life and direction within. In the light of these definitions, I close with the conception of Carlyle. The order and energy of the universe I hold to be inherent, and not imposed from without, the expression of fixed law and not of arbitrary will, exercised by what Carlyle would call an Almighty Clockmaker. But the two conceptions are not so much

opposed to each other after all. In one fundamental particular they at all events agree. They equally imply the interdependence and harmonious interaction of parts, and the subordination of the individual powers of the universal organism to the working of the whole.

Never were the harmony and interdependence just referred to so clearly recognised as now. Our insight regarding them is not that vague and general insight to which our fathers had attained, and which, in early times, was more frequently affirmed by the synthetic poet than by the scientific man. The interdependence of our day has become quantitative—expressible by numbers—leading, it must be added, directly into that inexorable reign of law which so many gentle people regard with dread. In the domain now under review men of science had first to work their way from darkness into twilight, and from twilight into day. There is no solution of continuity in science. It is not given to any man, however endowed, to rise spontaneously into intellectual splendour without the parentage of antecedent thought. Great discoveries grow. Here, as in other cases, we have first the seed, then the ear, then the full corn in the ear, the last member of the series implying the first. Thus, as regards the discovery of gravitation with which the name of Newton is identified, notions more or less clear concerning it had entered many minds before Newton's transcendent mathematical genius raised it to the level of a demonstration. The whole of his deductions, moreover, rested upon the inductions of Kepler. Newton shot beyond his predecessors; but his thoughts were rooted in their thoughts, and a just distribution of merit would assign to them a fair portion of the honour of discovery.

Scientific theories sometimes float like rumours in the air before they receive complete expression. The doom of a doctrine is often practically sealed, and the truth of one is often practically accepted, long prior to the demonstration of either the error or the truth. Perpetual motion was discarded before it was proved to be opposed to natural law; and, as regards the connection and interaction of natural forces, intimations of modern discoveries are strewn through the writings of Leibnitz, Boyle, Hooke, Locke, and others.

Confining ourselves to recent times, Dr. Ingleby has pointed out to me some singularly sagacious remarks bearing upon this question, which were published by an anonymous writer in 1820. Roget's penetration was conspicuous in 1829. Mohr had grasped in 1837 some deep-lying truth. The writings of Faraday furnish frequent illustrations of his profound belief in the unity of nature. "I have long," he writes in 1845, "held an opinion almost amounting to conviction, in common, I believe, with other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have one common origin, or, in other words, are so directly related and mutually dependent that they are convertible, as it were, one into another, and possess equivalence of power in their action." His own researches on magneto-electricity, on electro-chemistry, and on the "magnetisation of light," led him directly to this belief. At an early date Mr. Justice Grove made his mark upon this question. Colding, though starting from a metaphysical basis, grasped eventually the relation between heat and mechanical work, and sought to determine it experimentally. And here let me say, that to him who has only the truth at heart, and who in his dealings with scientific history keeps his soul unwarped by envy, hatred, or malice, personal or national, every fresh accession to historic knowledge must be welcome. For every new-comer of proved merit, more especially if that merit should have been previously overlooked, he makes ready room in his recognition or his reverence. But no retrospect of scientific literature has as yet brought to light a claim which can sensibly affect the positions accorded

to two great *Path-hewers*, as the Germans them, whose names in relation to subject are linked in indissoluble association. These names are Julius Robert Mayer and James Prescott Joule.

In his essay on "Circles" Mr. Emerson, if I remember rightly, pictured intellectual progress as rhythmic. At a given moment knowledge is surrounded by a barrier which marks its limit. It gradually gathers clearness and strength until by-and-by some thinker of exceptional power bursts the barrier and wins a wider circle, within which thought once more entrenches itself. But the internal force again accumulates, the new barrier is in its turn broken, and the mind finds itself surrounded by a still wider horizon. Thus, according to Emerson, knowledge spreads by intermittent victories instead of progressing at a uniform rate.

When Dr. Joule first proved that a weight of one pound, falling through a height of 772 feet, generated an amount of heat competent to warm a pound of water one degree Fahrenheit, and that in lifting the weight so much heat exactly disappeared, he broke an Emersonian "circle," releasing by the act an amount of scientific energy which rapidly overran a vast domain, and embodied itself in the great doctrine known as the "Conservation of Energy." This doctrine recognises in the material universe a constant sum of power made up of items among which the most Protean fluctuations are incessantly going on. It is as if the body of Nature were alive, the thrill and interchange of its energies resembling those of an organism. The parts of the "stupendous whole" shift and change, augment and diminish, appear and disappear, while the total of which they are the parts remains quantitatively immutable. Immutable, because when change occurs it is always polar—plus accompanies minus, gain accompanies loss, no item varying in the slightest degree without an absolutely equal change of some other item in the opposite direction.

The sun warms the tropical ocean, converting a portion of its liquid into vapour, which rises in the air and is recondensed on mountain heights, returning in rivers to the ocean from which it came. Up to the point where condensation begins, an amount of heat exactly equivalent to the molecular work of vaporisation and the mechanical work of lifting the vapour to the mountain-tops has disappeared from the universe. What is the gain corresponding to this loss? It will seem when mentioned to be expressed in a foreign currency. The loss is a loss of heat; the gain is a gain of distance, both as regards masses and molecules. Water which was formerly at the sea-level has been lifted to a position from which it can fall; molecules which have been locked together as a liquid are now separate as vapour which can recondense. After condensation gravity comes into effectual play, pulling the showers down upon the hills, and the rivers thus created through their gorges to the sea. Every raindrop which smites the mountain produces its definite amount of heat; every river in its course developes heat by the clash of its cataracts and the friction of its bed. In the act of condensation, moreover, the molecular work of vaporisation is accurately reversed. Compare, then, the primitive loss of solar warmth with the heat generated by the condensation of the vapour, and by the subsequent fall of the water from cloud to sea. They are mathematically equal to each other. No particle of vapour was formed and lifted without being paid for in the currency of solar heat; no particle returns as water to the sea without the exact quantitative restitution of that heat There is nothing gratuitous in physical nature, no expenditure without equivalent gain, no gain without equivalent expenditure. With inexorable constancy the one accompanies the other, leaving no nook or crevice between them for spontaneity to mingle with the pure and necessary play of natural force. Has this uniformity

of nature ever been broken? The reply is: "Not to the knowledge of science."

What has been here stated regarding heat and gravity applies to the whole of inorganic nature. Let us take an illustration from chemistry. The metal zinc may be burnt in oxygen, a perfectly definite amount of heat being produced by the combustion of a given weight of the metal. But zinc may also be burnt in a liquid which contains a supply of oxygen—in water, for example. It does not in this case produce flame or fire, but it does produce heat which is capable of accurate measurement. But the heat of zinc burnt in water falls short of that produced in pure oxygen, the reason being that to obtain its oxygen from the water the zinc must first dislodge the hydrogen. It is in the performance of this molecular work that the missing heat is absorbed. Mix the liberated hydrogen with oxygen and cause them to recombine; the heat developed is mathematically equal to the missing heat. Thus, in pulling the oxygen and hydrogen asunder an amount of heat is consumed which is accurately restored by their reunion.

This leads up to a few remarks upon the Voltaic battery. It is not my design to dwell upon the technical features of this wonderful instrument, but simply, by means of it, to show what varying shapes a given amount of energy can assume while maintaining unvarying quantitative stability. When that form of power which we call an electric current passes through Grove's battery, zinc is consumed in acidulated water; and in the battery we are able so to arrange matters that when no current passes no zinc shall be consumed. Now the current, whatever it may be, possesses the power of generating heat outside the battery. We can fuse with it iridium, the most refractory of metals, or we can produce with it the dazzling electric light, and that at any terrestrial distance from the battery itself.

We will now, however, content ourselves with causing the current to raise a given length of platinum wire, first to a blood-heat, then to redness, and finally to a white heat. The heat under these circumstances generated in the battery by the combustion of a fixed quantity of zinc is no longer constant, but it varies inversely as the heat generated outside. If the outside heat be *nil*, the inside heat is a maximum; if the external wire be raised to a blood-heat, the internal heat falls slightly short of the maximum. If the wire be rendered red-hot, the quantity of missing heat within the battery is greater, and if the external wire be rendered white-hot the defect is greater still. Add together the internal and external heat produced by the combustion of a given weight of zinc, and you have an absolutely constant total. The heat generated without is so much lost within, the heat generated within is so much lost without, the polar changes already adverted to coming here conspicuously into play. Thus in a variety of ways we can distribute the items of a never-varying sum, but even the subtle agency of the electric current places no creative power in our hands.

Instead of generating external heat, we may cause the current to effect chemical decomposition at a distance from the battery. Let it, for example, decompose water into oxygen and hydrogen. The heat generated in the battery under these circumstances by the combustion of a given weight of zinc falls short of what is produced when there is no decomposition. How far short? The question admits of a perfectly exact answer. When the oxygen and hydrogen recombine, the heat absorbed in the decomposition is accurately restored, and it is exactly equal in amount to that missing in the battery. We may, if we like, bottle up the gases, carry in this form the heat of the battery to the polar regions, and liberate it there. The battery, in fact, is a hearth on which fuel is consumed; but the heat of the combustion, instead of being confined in the usual manner to the hearth itself, may be first liberated at the other side of the world.

And here we are able to solve an enigma which long perplexed scientific men, and which could not be solved until the bearing of the mechanical theory of heat upon the phenomena of the Voltaic battery was understood. The puzzle was, that a single cell could not decompose water. The reason is now plain enough. The solution of an equivalent of zinc in a single cell developes not much more than half the amount of heat required to decompose an equivalent of water, and the single cell cannot cede an amount of force which it does not possess. But by forming a battery of two cells instead of one, we develop an amount of heat slightly in excess of that needed for the decomposition of the water. The two-celled battery is therefore rich enough to pay for that decomposition, and to maintain the excess referred to within its own cells.

Similar reflections apply to the thermo-electric pile, an instrument usually composed of small bars of bismuth and antimony soldered alternately together. The electric current is here evoked by warming the soldered junctions of one face of the pile. Like the Voltaic current, the thermo-electric current can heat wires, produce decomposition, magnetise iron, and deflect a magnetic needle at any distance from its origin. You will be disposed, and rightly disposed, to refer those distant manifestations of power to the heat communicated to the face of the pile, but the case is worthy of closer examination. In 1826 Thomas Seebeck discovered thermo-electricity, and six years subsequently Peltier made an observation which comes with singular felicity to our aid in determining the material used up in the formation of the thermo-electric current. He found that when a weak extraneous current was sent from antimony to bismuth the junction of the two metals was always heated, but that when the direction was from bismuth to antimony the junction was chilled. Now the current in the thermo-pile itself is always from bismuth to antimony, across the heated junction —a direction in which it cannot possibly establish itself without consuming the heat imparted to the junction. This heat is the nutriment of the current. Thus the heat generated by the thermo-current in a distant wire is simply that originally imparted to the pile which has been first transmuted into electricity, and then retransmuted into its first form at a distance from its origin. As water in a state of vapour passes from a boiler to a distant condenser, and there assumes its primitive form without gain or loss, so the heat communicated to the thermo-pile distils into the subtler electric current, which is, as it were, recondensed into heat in the distant platinum wire.

In my youth I thought an electro-magnetic engine which was shown to me a veritable perpetual motion—a machine, that is to say, which performed work without the expenditure of power. Let us consider the action of such a machine. Suppose it to be employed to pump water from a lower to a higher level. On examining the battery which works the engine we find that the zinc consumed does not yield its full amount of heat. The quantity of heat thus missing within is the exact thermal equivalent of the mechanical work performed without. Let the water fall again to the lower level; it is warmed by the fall. Add the heat thus produced to that generated by the friction, mechanical and magnetical, of the engine; we thus obtain the precise amount of heat missing in the battery. All the effects obtained from the machine are thus strictly paid for; this "payment for results" being, I would repeat, the inexorable method of nature.

No engine, however subtly devised, can evade this law of equivalence, or perform on its own account the smallest modicum of work. The machine distributes, but it cannot create. Is the animal body, then, to be classed among machines? When I lift a weight, or throw a stone, or climb a mountain, or wrestle with my comrade, am I not conscious of actually creating and expending

force? Let us look at the antecedents of this force. We derive the muscle and fat of our bodies from what we eat. Animal heat you know to be due to the slow combustion of this fuel. My arm is now inactive, and the ordinary slow combustion of my blood and tissue is going on. For every grain of fuel thus burnt a perfectly definite amount of heat has been produced. I now contract my biceps muscle without causing it to perform external work. The combustion is quickened, and the heat is increased; this additional heat being liberated in the muscle itself. I lay hold of a 56 lb. weight, and by the contraction of my biceps lift it through the vertical space of a foot. The blood and tissue consumed during this contraction have not developed in the muscle their due amount of heat. A quantity of heat is at this moment missing in my muscle which would raise the temperature of an ounce of water somewhat more than one degree Fahrenheit. I liberate the weight: it falls to the earth, and by its collision generates the precise amount of heat missing in the muscle. My muscular heat is thus transferred from its local hearth to external space. The fuel is consumed in my body, but the heat of combustion is produced outside my body. The case is substantially the same as that of the Voltaic battery when it performs external work, or produces external heat. All this points to the conclusion that the force we employ in muscular exertion is the force of burning fuel and not of creative will. In the light of these facts the body is seen to be as incapable of generating energy without expenditure, as the solids and liquids of the Voltaic battery. The body, in other words, falls into the category of machines.

We can do with the body all that we have already done with the battery—heat platinum wires, decompose water, magnetise iron, and deflect a magnetic needle. The combustion of muscle may be made to produce all these effects, as the combustion of zinc may be caused to produce them. By turning the handle of a magneto-electric machine a coil of wire may be caused to rotate between the poles of a magnet. As long as the two ends of the coil are unconnected we have simply to overcome the ordinary inertia and friction of the machine in turning the handle. But the moment the two ends of the coil are united by a thin platinum wire a sudden addition of labour is thrown upon the turning arm. When the necessary labour is expended, its equivalent immediately appears. The platinum wire glows. You can readily maintain it at a white heat, or even fuse it. This is a very remarkable result. From the muscles of the arm, with a temperature of 100°, we extract the temperature of molten platinum, which is nearly four thousand degrees. The miracle here is the reverse of that of the burning bush mentioned in Exodus. There the bush burned, but was not consumed: here the body is consumed, but does not burn. The similarity of the action with that of the Voltaic battery when it heats an external wire is too obvious to need pointing out. When the machine is used to decompose water, the heat of the muscle, like that of the battery, is consumed in molecular work, being fully restored when the gases recombine. As before, also, the transmuted heat of the muscles may be bottled up, carried to the polar regions, and there restored to its pristine form.

The matter of the human body is the same as that of the world around us; and here we find the forces of the human body identical with those of inorganic nature. Just as little as the Voltaic battery is the animal body a creator of force. It is an apparatus exquisite and effectual beyond all others in transforming and distributing the energy with which it is supplied, but it possesses no creative power. Compared with the notions previously entertained regarding the play of "vital force" this is a great result. The problem of vital dynamics

has been described by a competent authority as "the grandest of all." I subscribe to this opinion, and honour correspondingly the man who first successfully grappled with the problem. He was no pope, in the sense of being infallible, but he was a man of genius whose work will be held in honour as long as science endures. I have already named him in connection with our illustrious countryman Dr. Joule. Other eminent men took up this subject subsequently and independently, but all that has been done hitherto enhances instead of diminishing the merits of Dr. Mayer.

Consider the vigour of his reasoning. "Beyond the power of generating internal heat, the animal organism can generate heat external to itself. A blacksmith by hammering can warm a nail, and a savage by friction can heat wood to its point of ignition. Unless, then, we abandon the physiological axiom that the animal body cannot create heat out of nothing, we are driven to the conclusion that *it is the total heat, within and without, that ought to be regarded as the real calorific effect of the oxidation within the body.*" Mayer, however, not only states the principle, but illustrates numerically the transfer of muscular heat to external space. A bowler who imparts a velocity of 30 feet to an 8-lb. ball consumes in the act one-tenth of a grain of carbon. The heat of the muscle is here distributed over the track of the ball, being developed there by mechanical friction. A man weighing 150 lbs. consumes in lifting his own body to a height of 8 feet the heat of a grain of carbon. Jumping from this height the heat is restored. The consumption of 2 ozs. 4 drs. 20 grs. of carbon would place the same man on the summit of a mountain 10,000 feet high. In descending the mountain an amount of heat equal to that produced by the combustion of the foregoing amount of carbon is restored. The muscles of a labourer whose weight is 150 lbs. weigh 64 lbs. When dried they are reduced to 15 lbs. Were the oxidation corresponding to a day-labourer's ordinary work exerted on the muscles alone, they would be wholly consumed in 80 days. Were the oxidation necessary to sustain the heart's action concentrated on the heart itself, it would be consumed in 8 days. And if we confine our attention to the two ventricles, their action would consume the associated muscular tissue in 3½ days. With a fulness and precision of which this is but a sample did Mayer, between 1842 and 1845, deal with the great question of vital dynamics.

In direct opposition, moreover, to the foremost scientific authorities of that day, with Liebig at their head, this solitary Heilbronn worker was led by his calculations to maintain that the muscles, in the main, played the part of machinery, converting the fat, which had been previously considered a mere heat-producer, into the motive power of the organism. Mayer's prevision has been justified by events, for the scientific world is now upon his side.

We place, then, food in our stomachs as so much combustible matter. It is first dissolved by purely chemical processes, and the nutritive fluid is poured into the blood. Here it comes into contact with atmospheric oxygen admitted by the lungs. It unites with the oxygen as wood or coal might unite with it in a furnace. The matter-products of the union, if I may use the term, are the same in both cases, viz. carbonic acid and water. The force-products are also the same—heat within the body, or heat and work outside the body. Thus far every action of the organism belongs to the domain either of physics or of chemistry. But you saw me contract the muscle of my arm. What enabled me to do so? Was it or was it not the direct action of my will? The answer is, the action of the will is mediate, not direct. Over and above the muscles the human organism is provided with long whitish filaments of medullary matter, which issue from the spinal column, being connected by it on the one side with the brain, and on the other side

losing themselves in the muscles. Those filaments or cords are the nerves, which you know are divided into two kinds, sensor and motor, or, if you like the terms better, afferent and efferent nerves. The former carry impressions from the external world to the brain; the latter convey the behests of the brain to the muscles. Here, as elsewhere, we find ourselves aided by the sagacity of Mayer, who was the first clearly to formulate the part played by the nerves in the organism. Mayer saw that neither nerves nor brain, nor both together, possessed the energy necessary to animal motion; but he also saw that the nerve could lift a latch and open a door, by which floods of energy are let loose. "As an engineer," he says with admirable lucidity, "by the motion of his finger in opening a valve or loosening a detent, can liberate an amount of mechanical energy almost infinite compared with its exciting cause; so the nerves, acting on the muscles, can unlock an amount of power out of all proportion to the work done by the nerves themselves." The nerves, according to Mayer, pull the trigger, but the gunpowder which they ignite is stored in the muscles. This is the view now universally entertained.

The quickness of thought has passed into a proverb, and the notion that any measurable time elapsed between the infliction of a wound and the feeling of the injury would have been rejected as preposterous thirty years ago. Nervous impressions, notwithstanding the results of Haller, were thought to be transmitted, if not instantaneously, at all events with the rapidity of electricity. Hence, when Helmholtz, in 1851, affirmed, as the result of experiment, nervous transmission to be a comparatively sluggish process, very few believed him. His experiments may now be made in the lecture-room. Sound in air moves at the rate of 1,100 feet a second; sound in water moves at the rate of 5,000 feet a second; light in ether moves at the rate of 186,000 miles a second, and electricity in free wires moves probably at the same rate.* But the nerves transmit their messages at the rate of only 70 feet a second, a progress which in these quick times might well be regarded as inordinately slow.

Your townsman, Mr. Gore, has produced by electrolysis a kind of antimony which exhibits an action strikingly analogous to that of nervous propagation. A rod of this antimony is in such a molecular condition that when you scratch or heat one end of the rod the disturbance propagates itself before your eyes to the other end, the onward march of the disturbance being announced by the development of heat and fumes along the line of propagation. In some such way the molecules of the nerves are successively overthrown; and if Mr. Gore could only devise some means of winding up his exhausted antimony, as the nutritive blood winds up exhausted nerves, the comparison would be complete. The subject may be summed up, as Du Bois-Reymond has summed it up, by reference to the case of a whale struck by a harpoon in the tail. If the animal were seventy feet long, a second would elapse before the disturbance could reach the brain. But the impression after its arrival has to diffuse itself and throw the brain into the molecular condition necessary to consciousness. Then, and not till then, the command to the tail to defend itself is shot through the motor nerves. Another second must elapse before the command can reach the tail, so that more than two seconds transpire between the infliction of the wound and the muscular response of the part wounded. The interval required for the kindling of consciousness would probably more than suffice for the destruction of the brain by lightning, or even by a rifle-bullet. Before the organ can arrange itself it may, therefore, be destroyed, and in such a case we may safely conclude that death is painless.

The experiences of common life supply us with copious instances of the liberation of vast stores of muscular power

by an infinitesimal "priming" of the muscles by the nerves. We all know the effect produced on a "nervous" organisation by a slight sound which causes affright. An aërial wave, the energy of which would not reach a minute fraction of that necessary to raise the thousandth of a grain through the thousandth of an inch, can throw the whole human frame into a powerful mechanical spasm, followed by violent respiration and palpitation. The eye, of course, may be appealed to as well as the ear. Of this the lamented Lange gives the following vivid illustration:—

A merchant sits complacently in his easy chair, not knowing whether smoking, sleeping, newspaper reading, or the digestion of food occupies the largest portion of his personality. A servant enters the room with a telegram, bearing the words, "Antwerp, etc.......Jonas and Co. have failed." "Tell James to harness the horses!" The servant flies. Up starts the merchant, wide awake, makes a dozen paces through the room, descends to the counting-house, dictates letters, and forwards despatches. He jumps into his carriage, the horses snort, and their driver is immediately at the Bank, on the Bourse, and among his commercial friends. Before an hour has elapsed he is again at home, where he throws himself once more into his easy chair with a deep-drawn sigh: "Thank God I am protected against the worst, and now for further reflection."

This complex mass of action, emotional, intellectual, and mechanical, is evoked by the impact upon the retina of the infinitesimal waves of light coming from a few pencil marks on a bit of paper. We have, as Lange says, terror, hope, sensation, calculation, possible ruin, and victory compressed into a moment. What caused the merchant to spring out of his chair? The contraction of his muscles. What made his muscles contract? An impulse of the nerves, which lifted the proper latch, and liberated the muscular power. Whence this impulse? From the centre of the nervous system. But how did it originate there? This is the critical question, to which some will reply that it had its origin in the human soul.

The aim and effort of science is to explain the unknown in terms of the known. Explanation, therefore, is conditioned by knowledge. You have probably heard the story of the German peasant who, in early railway days, was taken to see the performance of a locomotive. He had never known carriages to be moved except by animal power. Every explanation outside of this conception lay beyond his experience, and could not be invoked. After long reflection, therefore, and seeing no possible escape from the conclusion, he exclaimed confidently to his companion, "Es müssen doch Pferde darin sein"—"There must be horses inside." Amusing as this locomotive theory may seem, it illustrates a deep-lying truth.

With reference to our present question, some may be disposed to press upon me such considerations as these:—Your motor-nerves are so many speaking-tubes, through which messages are sent from the man to the world; and your sensor nerves are so many conduits through which the whispers of the world are sent back to the man. But you have not told us where *is* the man. Who or what is it that sends and receives those messages through the bodily organism? Do not the phenomena point to the existence of a self within the self, which acts through the body as through a skilfully constructed instrument? You picture the muscles as hearkening to the commands sent through the motor nerves, and you picture the sensor nerves as the vehicles of incoming intelligence; are you not bound to supplement this mechanism by the assumption of an entity which uses it? In other words, are you not forced by your own exposition into the hypothesis of a free human soul?

This is fair reasoning now, and at a certain stage of the world's knowledge it might well have been deemed conclusive. Adequate reflection, however,

shows that, instead of introducing light into our minds, this hypothesis considered scientifically increases our darkness. You do not in this case explain the unknown in terms of the known, which, as stated above, is the method of science, but you explain the unknown in terms of the more unknown. Try to mentally visualise this soul as an entity distinct from the body, and the difficulty immediately appears. From the side of science all that we are warranted in stating is that the terror, hope, sensation, and calculation of Lange's merchant are psychical phenomena produced by, or associated with, the molecular processes set up by waves of light in a previously prepared brain.

When facts present themselves let us dare to face them, but let the man of science equally dare to confess ignorance where it prevails. What then is the causal connection, if any, between the objective and subjective—between molecular motions and states of consciousness? My answer is: I do not see the connection, nor have I as yet met anybody who does. It is no explanation to say that the objective and subjective effects are two sides of one and the same phenomenon. Why should the phenomenon have two sides? This is the very core of the difficulty. There are plenty of molecular motions which do not exhibit this two-sidedness. Does water think or feel when it runs into frost-ferns upon a window-pane? If not, why should the molecular motion of the brain be yoked to this mysterious companion—consciousness? We can form a coherent picture of the physical processes—the stirring of the brain, the thrilling of the nerves, the discharging of the muscles, and all the subsequent mechanical motions of the organism. But we can present to our minds no picture of the process whereby consciousness emerges, either as a necessary link or as an accidental by-product of this series of actions. Yet it certainly does emerge—the prick of a pin suffices to prove that molecular motion can produce consciousness. The reverse process of the production of motion by consciousness is equally unpresentable to the mind. We are here, in fact, upon the boundary line of the intellect, where the ordinary canons of science fail to extricate us from our difficulties. If we are true to these canons, we must deny to subjective phenomena all influence on physical processes. Observation proves that they interact, but in passing from one to the other we meet a blank which mechanical deduction is unable to fill. Frankly stated, we have here to deal with facts almost as difficult to seize mentally as the idea of a soul. And if you are content to make your "soul" a poetic rendering of a phenomenon which refuses the yoke of ordinary physical laws, I, for one, would not object to this exercise of ideality. Amid all our speculative uncertainty, however, there is one practical point as clear as the day; namely, that the brightness and the usefulness of life, as well as its darkness and disaster, depend to a great extent upon our own use or abuse of this miraculous organ.

Accustomed as I am to harsh language, I am quite prepared to hear my "poetic rendering" branded as a "falsehood" and a "fib." The vituperation is unmerited, for poetry or ideality and untruth are assuredly very different things. The one may vivify, while the other kills. When St. John extends the notion of a soul to "souls washed in the blood of Christ" does he "fib"? Indeed, if the appeal to ideality is censurable, Christ himself ought not to have escaped censure. Nor did he escape it. "How can this man give us his flesh to eat?" expressed the sceptical flouting of unpoetic natures. Such are still among us. Cardinal Manning would doubtless tell any Protestant who rejects the doctrine of transubstantiation that he "fibs" away the plain words of his Saviour when he reduces "the Body of the Lord" in the sacrament to a mere figure of speech.

Though misuse may render it grotesque or insincere, the idealisation of ancient

conceptions, when done consciously and above board, has, in my opinion, an important future. We are not radically different from our historic ancestors, and any feeling which affected them profoundly requires only appropriate clothing to affect us. The world will not lightly relinquish its heritage of poetic feeling, and metaphysic will be welcomed when it abandons its pretensions to scientific discovery and consents to be ranked as a kind of poetry. "A good symbol," says Emerson, "is a missionary to persuade thousands. The Vedas, the Edda, the Koran, are each remembered by its happiest figure. There is no more welcome gift to men than a new symbol. They assimilate themselves to it, deal with it in all ways, and it will last a hundred years. Then comes a new genius and brings another." Our ideas of God and the soul are obviously subject to this symbolic mutation. They are not now what they were a century ago. They will not be a century hence what they are now. Such ideas constitute a kind of central energy in the human mind, capable, like the energy of the physical universe, of assuming various shapes and undergoing various transformations. They baffle and elude the theological mechanic who would carve them to dogmatic forms. They offer themselves freely to the poet who understands his vocation, and whose function is, or ought to be, to find "local habitation" for thoughts woven into our subjective life, but which refuse to be mechanically defined.

We now stand face to face with the final problem. It is this: Are the brain, and the moral and intellectual processes known to be associated with the brain—and, as far as our experience goes, indissolubly associated—subject to the laws which we find paramount in physical nature? Is the will of man, in other words, free, or are it and nature equally "bound fast in fate"? From this latter conclusion, after he had established it to the entire satisfaction of his understanding, the great German thinker Fichte recoiled. You will find the record of this struggle between head and heart in his book, entitled *Die Bestimmung des Menschen*—The Vocation of Man.[1] Fichte was determined at all hazards to maintain his freedom, but the price he paid for it indicates the difficulty of the task. To escape from the iron necessity seen everywhere reigning in physical nature, he turned defiantly round upon nature and law, and affirmed both of them to be the products of his own mind. He was not going to be the slave of a thing which he had himself created. There is a good deal to be said in favour of this view, but few of us probably would be able to bring into play the solvent transcendentalism whereby Fichte melted his chains.

Why do some regard this notion of necessity with terror, while others do not fear it at all? Has not Carlyle somewhere said that a belief in destiny is the bias of all earnest minds? "It is not Nature," says Fichte, "it is Freedom itself, by which the greatest and most terrible disorders incident to our race are produced. Man is the cruellest enemy of man." But the question of moral responsibility here emerges, and it is the possible loosening of this responsibility that so many of us dread. The notion of necessity certainly failed to frighten Bishop Butler. He thought it untrue—even absurd—but he did not fear its practical consequences. He showed, on the contrary, in the *Analogy*, that as far as human conduct is concerned the two theories of free-will and necessity would come to the same in the end.

What is meant by free-will? Does it imply the power of producing events without antecedents?—of starting, as it were, upon a creative tour of occurrences without any impulse from within or from without? Let us consider the point. If there be absolutely or relatively no reason why a tree should fall, it will not

[1] Translated by Dr. William Smith, of Edinburgh; Trübner, 1873.

fall; and if there be absolutely or relatively no reason why a man should act, he will not act. It is true that the united voice of this assembly could not persuade me that I have not, at this moment, the power to lift my arm if I wished to do so. Within this range the conscious freedom of my will cannot be questioned. But what about the origin of the "wish"? Are we, or are we not, complete masters of the circumstances which create our wishes, motives, and tendencies to action? Adequate reflection will, I think, prove that we are not. What, for example, have I had to do with the generation and development of that which some will consider my total being, and others a most potent factor of my total being—the living, speaking organism which now addresses you? As stated at the beginning of this discourse, my physical and intellectual textures were woven *for* me, not *by* me. Processes in the conduct or regulation of which I had no share have made me what I am. Here, surely, if anywhere, we are as clay in the hands of the potter. It is the greatest of delusions to suppose that we come into this world as sheets of white paper, on which the age can write anything it likes, making us good or bad, noble or mean, as the age pleases. The age can stunt, promote, or pervert pre-existent capacities, but it cannot create them. The worthy Robert Owen, who saw in external circumstances the great moulders of human character, was obliged to supplement his doctrine by making the man himself one of the circumstances. It is as fatal as it is cowardly to blink facts because they are not to our taste. How many disorders, ghostly and bodily, are transmitted to us by inheritance? In our courts of law, whenever it is a question whether a crime has been committed under the influence of insanity, the best guidance the judge and jury can have is derived from the parental antecedents of the accused. If among these insanity be exhibited in any marked degree, the presumption in the prisoner's favour is enormously enhanced, because the experience of life has taught both judge and jury that insanity is frequently transmitted from parent to child.

I met, some years ago, in a railway carriage the governor of one of our largest prisons. He was evidently an observant and reflective man, possessed of wide experience gathered in various parts of the world, and a thorough student of the duties of his vocation. He told me that the prisoners in his charge might be divided into three distinct classes. The first class consisted of persons who ought never to have been in prison. External accident, and not internal taint, had brought them within the grasp of the law, and what had happened to them might happen to most of us. They were essentially men of sound moral stamina, though wearing the prison garb. Then came the largest class, formed of individuals possessing no strong bias, moral or immoral, plastic to the touch of circumstances, which could mould them into either good or evil members of society. Thirdly came a class—happily not a large one—whom no kindness could conciliate and no discipline tame. They were sent into this world labelled "incorrigible," wickedness being stamped, as it were, upon their organisations. It was an unpleasant truth, but, as a truth, it ought to be faced. For such criminals the prison over which he ruled was certainly not the proper place. If confined at all, their prison should be on a desert island, where the deadly contagium of their example could not taint the moral air. But the sea itself he was disposed to regard as a cheap and appropriate substitute for the island. It seemed to him evident that the State would benefit if prisoners of the first class were liberated; prisoners of the second class educated; and prisoners of the third class put compendiously under water.

It is not, however, from the observation of individuals that the argument against "free-will," as commonly understood, derives its principal force. It is, as already hinted, indefinitely strengthened

when extended to the race. Most of you have been forced to listen to the outcries and denunciations which rang discordant through the land for some years after the publication of Mr. Darwin's *Origin of Species*. Well, the world—even the clerical world—has for the most part settled down in the belief that Mr. Darwin's book simply reflects the truth of nature: that we who are now "foremost in the files of time" have come to the front through almost endless stages of promotion from lower to higher forms of life.

If to any one of us were given the privilege of looking back through the æons across which life has crept towards its present outcome, his vision, according to Darwin, would ultimately reach a point when the progenitors of this assembly could not be called human. From that humble society, through the interaction of its members and the storing up of their best qualities, a better one emerged; from this again a better still; until at length, by the integration of infinitesimals through ages of amelioration, we came to be what we are to-day. We of this generation had no conscious share in the production of this grand and beneficent result. Any and every generation which preceded us had just as little share. The favoured organisms whose garnered excellence constitutes our present store owed their advantages, first, to what we in our ignorance are obliged to call "accidental variation"; and, secondly, to a law of heredity in the passing of which our suffrages were not collected. With characteristic felicity and precision Mr. Matthew Arnold lifts this question into the free air of poetry, but not out of the atmosphere of truth, when he ascribes the process of amelioration to "a power not ourselves which makes for righteousness." If, then, our organisms, with all their tendencies and capacities, are given to us without our being consulted; and if, while capable of acting within certain limits in accordance with our wishes, we are not masters of the circumstances in which motives and wishes originate; if, finally, our motives and wishes determine our actions —in what sense can these actions be said to be the result of free-will?

Here, again, we are confronted with the moral responsibility, which, as it has been much talked of lately, it is desirable to meet. With the view of removing the fear of our falling back into the condition of "the ape and tiger," so sedulously excited by certain writers, I propose to grapple with this question in its rudest form, and in the most uncompromising way. "If," says the robber, the ravisher, or the murderer, "I act because I must act, what right have you to hold me responsible for my deeds?" The reply is, "The right of society to protect itself against aggressive and injurious forces, whether they be bond or free, forces of nature or forces of man." "Then," retorts the criminal, "you punish me for what I cannot help." "Let it be granted," says society; "but had you known that the treadmill or the gallows was certainly in store for you, you might have 'helped.' Let us reason the matter fully and frankly out. We may entertain no malice or hatred against you; it is enough that with a view to our own safety and purification we are determined that you and such as you shall not enjoy liberty of evil action in our midst. You, who have behaved as a wild beast, we claim the right to cage or kill as we should a wild beast. The public safety is a matter of more importance than the very limited chance of your moral renovation, while the knowledge that you have been hanged by the neck may furnish to others about to do as you have done the precise motive which will hold them back. If your act be such as to invoke a minor penalty, then not only others, but yourself, may profit by the punishment which we inflict. On the homely principle that 'a burnt child dreads the fire,' it will make you think twice before venturing on a repetition of your crime. Observe, finally, the consistency of our conduct. You offend,

you say, because you cannot help offending, to the public detriment. We punish, is our reply, because we cannot help punishing, for the public good. Practically, then, as Bishop Butler predicted, we act as the world acted when it supposed the evil deeds of its criminals to be the products of free-will."[1]

"What," I have heard it argued, "is the use of preaching about duty if a man's predetermined position in the moral world renders him incapable of profiting by advice?" Who knows that he is incapable? The preacher's last word is a factor in the man's conduct, and it may be a most important factor, unlocking moral energies which might otherwise remain imprisoned and unused. If the preacher thoroughly feel that words of enlightenment, courage, and admonition enter into the list of forces employed by Nature herself for man's amelioration, since she gifted man with speech, he will suffer no paralysis to fall upon his tongue. Dung the fig-tree hopefully, and not until its barrenness has been demonstrated beyond a doubt let the sentence go forth, "Cut it down, why cumbereth it the ground?"

I remember when a youth in the town of Halifax, some two and thirty years ago, attending a lecture given by a young man to a small but select audience. The aspect of the lecturer was earnest and practical, and his voice soon rivetted attention. He spoke of duty, defining it as a debt owed, and there was a kindling vigour in his words which must have strengthened the sense of duty in the minds of those who heard him. No speculations regarding the freedom of the will could alter the fact that the words of that young man did me good. His name was George Dawson. He also spoke, if you will allow me to allude to it, of a social subject much discussed at the time—the Chartist subject of "levelling." Suppose, he says, two men to be equal at night, and that one rises at six, while the other sleeps till nine next morning, what becomes of your levelling? And, in so speaking, he made himself the mouthpiece of Nature, which, as we have seen, secures advance, not by the reduction of all to a common level, but by the encouragement and conservation of what is best.

It may be urged that, in dealing as above with my hypothetical criminal, I am assuming a state of things brought about by the influence of religions which include the dogmas of theology and the belief in free-will—a state, namely, in which a moral majority control and keep in awe an immoral minority. The heart of man is deceitful above all things, and desperately wicked. Withdraw, then, our theologic sanctions, including the belief in free-will, and the condition of the race will be typified by the samples of individual wickedness which have been above adduced. We shall, that is, become robbers, and ravishers, and murderers. From much that has been written of late it would seem that this astounding inference finds house-room in many minds. Possibly, the people who hold such views might be able to illustrate them by individual instances.

> "The fear of hell's a hangman's whip,
> To keep the wretch in order."

Remove the fear, and the wretch, following his natural instinct, may become disorderly; but I refuse to accept him as a sample of humanity. "Let us eat and drink, for to-morrow we die" is by no means the ethical consequence of a rejection of dogma. To many of you the name of George Jacob Holyoake is doubtless familiar, and you are probably aware that at no man in England has the term "atheist" been more frequently pelted. There are, moreover, really few who have more completely liberated themselves from theologic notions. Among working-class politicians Mr. Holyoake is a leader. Does he exhort his followers to "Eat and drink, for to-morrow we die"? Not so. In the

[1] An eminent Church dignitary describes all this, not unkindly, as "truculent logic." I think it worthy of his Grace's graver consideration.

August number of the *Nineteenth Century* you will find these words from his pen: "The gospel of dirt is bad enough, but the gospel of mere material comfort is much worse." He contemptuously calls the Comtist championship of the working man "the championship of the trencher." He would place "the leanest liberty which brought with it the dignity and power of self-help" higher than "any prospect of a full plate without it." Such is the moral doctrine taught by this "atheistic" leader; and no Christian, I apprehend, need be ashamed of it.

Most heartily do I recognise and admire the spiritual radiance, if I may use the term, shed by religion on the minds and lives of many personally known to me. At the same time I cannot but observe how signally, as regards the production of anything beautiful, religion fails in other cases. Its professor and defender is sometimes at bottom a brawler and a clown. These differences depend upon primary distinctions of character which religion does not remove. It may comfort some to know that there are among us many whom the gladiators of the pulpit would call "atheists" and "materialists," whose lives, nevertheless, as tested by any accessible standard of morality, would contrast more than favourably with the lives of those who seek to stamp them with this offensive brand. When I say "offensive," I refer simply to the intention of those who use such terms, and not because atheism or materialism, when compared with many of the notions ventilated in the columns of religious newspapers, has any particular offensiveness for me. If I wished to find men who are scrupulous in their adherence to engagements, whose words are their bond, and to whom moral shiftiness of any kind is subjectively unknown; if I wanted a loving father, a faithful husband, an honourable neighbour, and a just citizen —I should seek him, and find him, among the band of "atheists" to which I refer. I have known some of the most pronounced among them not only in life but in death—seen them approaching with open eyes the inexorable goal, with no dread of a "hangman's whip," with no hope of a heavenly crown, and still as mindful of their duties, and as faithful in the discharge of them, as if their eternal future depended upon their latest deeds.

In letters addressed to myself, and in utterances addressed to the public, Faraday is often referred to as a sample of the association of religious faith with moral elevation. I was locally intimate with him for fourteen or fifteen years of my life, and had thus occasion to observe how nearly his character approached what might, without extravagance, be called perfection. He was strong but gentle, impetuous but self-restrained; a sweet and lofty courtesy marked his dealings with men and women; and though he sprang from the body of the people, a nature so fine might well have been distilled from the flower of antecedent chivalry. Not only in its broader sense was the Christian religion necessary to Faraday's spiritual peace, but in what many would call the narrow sense held by those described by Faraday himself as "a very small and despised sect of Christians, known, if known at all, as Sandemanians," it constituted the light and comfort of his days.

Were our experience confined to such cases, it would furnish an irresistible argument in favour of the association of dogmatic religion with moral purity and grace. But, as already intimated, our experience is not thus confined. In further illustration of this point, we may compare with Faraday a philosopher of equal magnitude, whose character, including gentleness and strength, candour and simplicity, intellectual power and moral elevation, singularly resembles that of the great Sandemanian, but who has neither shared the theologic views nor the religious emotions which formed so dominant a factor in Faraday's life. I allude to Mr. Charles Darwin, the Abraham of scientific men—a searcher as obedient to the command of truth as was the patriarch to the command of God.

I cannot, therefore, as so many desire, look upon Faraday's religious belief as the exclusive source of qualities shared so conspicuously by one uninfluenced by that belief. To a deeper virtue belonging to human nature in its purer forms I am disposed to refer the excellence of both.

Superstition may be defined as constructive religion, which has grown incongruous with intelligence. We may admit, with Fichte, "that superstition has unquestionably constrained its subjects to abandon many pernicious practices and to adopt many useful ones"; the real loss accompanying its decay at the present day has been thus clearly stated by the same philosopher: "In so far as these lamentations do not proceed from the priests themselves—whose grief at the loss of their dominion over the human mind we can well understand—but from the politicians, the whole matter resolves itself into this, that government has thereby become more difficult and expensive. The judge was spared the exercise of his own sagacity and penetration when, by threats of relentless damnation, he could compel the accused to make confession. The evil spirit formerly performed without reward services for which in later times judges and policemen have to be paid."

No man ever felt the need of a high and ennobling religion more thoroughly than this powerful and fervid teacher, who, by the way, did not escape the brand of "atheist." But Fichte asserted emphatically the power and sufficiency of morality in its own sphere. "Let us consider," he says, "the highest which man can possess in the absence of religion—I mean pure morality. The moral man obeys the law of duty in his breast absolutely, because it is a law unto him; and he does whatever reveals itself to him as his duty simply because it is duty. Let not the impudent assertion be repeated that such an obedience, without regard to consequences, and without desire for consequences, is in itself impossible and opposed to human nature." So much for Fichte. Faraday was equally distinct. "I have no intention," he says, "of substituting anything for religion, but I wish to take that part of human nature which is independent of it. Morality, philosophy, commerce, the various institutions and habits of society, are independent of religion and may exist without it." These were the words of his youth, but they expressed his latest convictions. I would add that the muse of Tennyson never reached a higher strain than when it embodied the sentiment of duty in Œnone:—

> "And, because right is right, to follow right
> Were wisdom in the scorn of consequence."

Not in the way assumed by our dogmatic teachers has the morality of human nature been built up. The power which has moulded us thus far has worked with stern tools upon a very rigid stuff. What it has done cannot be so readily undone; and it has endowed us with moral constitutions which take pleasure in the noble, the beautiful, and the true, just as surely as it has endowed us with sentient organisms, which find aloes bitter and sugar sweet. That power did not work with delusions, nor will it stay its hand when such are removed. Facts, rather than dogmas, have been its ministers—hunger and thirst, heat and cold, pleasure and pain, fervour, sympathy, aspiration, shame, pride, love, hate, terror, awe—such were the forces whose interaction and adjustment throughout an immeasurable past wove the triplex web of man's physical, intellectual, and moral nature, and such are the forces that will be effectual to the end.

You may retort that even on my own showing "the power which makes for righteousness" *has* dealt in delusions; for it cannot be denied that the beliefs of religion, including the dogmas of theology and the freedom of the will, have had some effect in moulding the moral world. Granted; but I do not think that this goes to the root of the matter. Are you quite sure that those beliefs and dogmas are primary, and not derived?—that they are not the *products*,

instead of being the *creators*, of man's moral nature? I think it is in one of the Latter-Day Pamphlets that Carlyle corrects a reasoner, who deduced the nobility of man from a belief in heaven, by telling him that he puts the cart before the horse, the real truth being that the belief in heaven is derived from the nobility of man. The bird's instinct to weave its nest is referred to by Emerson as typical of the force which built cathedrals, temples, and pyramids:—

"Knowest thou what wove yon woodbird's nest
Of leaves and feathers from her breast,
Or how the fish outbuilt its shell,
Painting with morn each annual cell?
Such and so grew these holy piles
While love and terror laid the tiles;
Earth proudly wears the Parthenon
As the best gem upon her zone;
And Morning opes with haste her lids
To gaze upon the Pyramids;
O'er England's abbeys bends the sky
As on its friends with kindred eye;
For ut of Thought's interior sphere
These wonders rose to upper air,
And nature gladly gave them place,
Adopted them into her race,
And granted them an equal date
With Andes and with Ararat."

Surely, many utterances which have been accepted as descriptions ought to be interpreted as aspirations, or as having their roots in aspiration instead of in objective knowledge. Does the song of the herald angels, "Glory to God in the highest, and on earth peace, goodwill toward men," express the exaltation and the yearning of a human soul? or does it describe an optical and acoustical fact —a visible host and an audible song? If the former, the exaltation and the yearning are man's imperishable possession—a ferment long confined to individuals, but which may by-and-by become the leaven of the race. If the latter, then belief in the entire transaction is wrecked by non-fulfilment. Look to the East at the present moment as a comment on the promise of peace on earth and goodwill toward men. That promise is a dream ruined by the experience of eighteen centuries, and in that ruin is involved the claim of the "heavenly host" to prophetic vision. But though the mechanical theory proves untenable, the immortal song and the feelings it expresses are still ours, to be incorporated, let us hope, in purer and less shadowy forms in the poetry, philosophy, and practice of the future.

Thus, following the lead of physical science, we are brought without solution of continuity into the presence of problems which, as usually classified, lie entirely outside the domain of physics. To these problems thoughtful and penetrative minds are now applying those methods of research which in physical science have proved their truth by their fruits. There is on all hands a growing repugnance to invoke the supernatural in accounting for the phenomena of human life; and the thoughtful minds just referred to, finding no trace of evidence in favour of any other origin, are driven to seek in the interaction of social forces the genesis and development of man's moral nature. If they succeed in their search—and I think they are sure to succeed—social duty will be raised to a higher level of significance, and the deepening sense of social duty will, it is to be hoped, lessen, if not obliterate, the strifes and heartburnings which now beset and disfigure our social life. Towards this great end it behoves us one and all to work; and devoutly wishing its consummation, I have the honour, ladies and gentlemen, to bid you a friendly farewell.

VITALITY

[1863]

THE origin, growth, and energies of living things are subjects which have always engaged the attention of thinking men. To account for them it was usual to assume a special agent, free to a great extent from the limitations observed among the powers of inorganic nature. This agent was called *vital force;* and, under its influence, plants and animals were supposed to collect their materials and to assume determinate forms. Within the last few years, however, our ideas of vital processes have undergone profound modifications; and the interest, and even disquietude, which the change has excited are amply evidenced by the discussions and protests which are now common regarding the phenomena of vitality. In tracing these phenomena through all their modifications, the most advanced philosophers of the present day declare that they ultimately arrive at a single source of power, from which all vital energy is derived; and the disquieting circumstance is that this source is not the direct fiat of a supernatural agent, but a reservoir of what, if we do not accept the creed of Zoroaster, must be regarded as *inorganic* force. In short, it is considered as proved that all the energy which we derive from plants and animals is drawn from the sun.

A few years ago, when the sun was affirmed to be the source of life, nine out of ten of those who are alarmed by the form which this assertion has latterly assumed would have assented, in a general way, to its correctness. Their assent, however, was more poetic than scientific, and they were by no means prepared to see a rigid mechanical signification attached to their words. This, however, is the peculiarity of modern conclusions: that there is no creative energy whatever in the vegetable or animal organism, but that all the power which we obtain from the muscles of man and animals, as much as that which we develop by the combustion of wood or coal, has been produced at the sun's expense. The sun is so much the colder that we may have our fires; he is also so much the colder that we may have our horse-racing and Alpine climbing. It is, for example, certain that the sun has been chilled to an extent capable of being accurately expressed in numbers, in order to furnish the power which lifted this year a certain number of tourists from the vale of Chamouni to the summit of Mont Blanc.

To most minds, however, the energy of light and heat presents itself as a thing totally distinct from ordinary mechanical energy. Either of them can nevertheless be derived from the other. Wood can be raised by friction to the temperature of ignition; while by properly striking a piece of iron a skilful blacksmith can cause it to glow. Thus, by the rude agency of his hammer, he generates light and heat. This action, if carried far enough, would produce the light and heat of the sun. In fact, the sun's light and heat have actually been referred to the fall of meteoric matter upon his surface; and, whether the sun is thus supported or not, it is perfectly certain that he *might be* thus supported. Whether, moreover, the whilom molten condition of our planet was, as supposed by eminent men, due to the collision of cosmic masses or not, it is perfectly certain that the molten condition *might be* thus brought about. If, then, solar light and heat can be produced by the impact of dead matter, and if from the light and heat thus produced we can derive the energies which we have been accustomed to call *vital,* it indubitably follows that vital energy may have a proximately mechanical origin.

In what sense, then, is the sun to be regarded as the origin of the energy derivable from plants and animals? Let

us try to give an intelligible answer to this question. Water may be raised from the sea-level to a high elevation, and then permitted to descend. In descending it may be made to assume various forms—to fall in cascades, to spurt in fountains, to boil in eddies, or to flow tranquilly along a uniform bed. It may, moreover, be caused to set complex machinery in motion, to turn millstones, throw shuttles, work saws and hammers, and drive piles. But every form of power here indicated would be derived from the original power expended in raising the water to the height from which it fell. There is no energy *generated* by the machinery; the work performed by the water in descending is merely the parcelling out and distribution of the work expended in raising it. In precisely this sense is all the energy of plants and animals the parcelling out and distribution of a power originally exerted by the sun. In the case of the water, the source of the power consists in the forcible separation of a quantity of the liquid from a low level of the earth's surface and its elevation to a higher position, the power thus expended being returned by the water in its descent. In the case of vital phenomena, the source of power consists in the forcible separation of the atoms of compound substances by the sun. We name the force which draws the water earthward "gravity," and that which draws atoms together "chemical affinity"; but these different names must not mislead us regarding the qualitative identity of the two forces. They are both *attractions*; and to the intellect the falling of carbon atoms against oxygen atoms is not more difficult of conception than the falling of water to the earth.

The building up of the vegetable, then, is effected by the sun, through the reduction of chemical compounds. The phenomena of animal life are more or less complicated reversals of these processes of reduction. We eat the vegetable and we breathe the oxygen of the air; and in our bodies the oxygen, which has been lifted from the carbon and hydrogen by the action of the sun, again falls towards them, producing animal heat and developing animal forms. Through the most complicated phenomena of vitality this law runs: the vegetable is produced while a weight rises; the animal is produced while a weight falls. But the question is not exhausted here. The water employed in our first illustration generates all the motion displayed in its descent, but the *form* of the motion depends on the character of the machinery interposed in the path of the water. In a similar way the primary action of the sun's rays is qualified by the atoms and molecules among which their energy is distributed. Molecular forces determine the form which the solar energy will assume. In the separation of the carbon and oxygen this energy may be so conditioned as to result in one case in the formation of a cabbage and in another case in the formation of an oak. So also, as regards the reunion of the carbon and the oxygen, the molecular machinery through which the combining energy acts may in one case weave the texture of a frog, while in another it may weave the texture of a man.

The matter of the animal body is that of inorganic nature. There is no substance in the animal tissues which is not primarily derived from the rocks, the water, and the air. Are the forces of organic matter, then, different in kind from those of inorganic matter? The philosophy of the present day negatives the question. It is the compounding, in the organic world, of forces belonging equally to the inorganic that constitutes the mystery and the miracle of vitality. Every portion of every animal body may be reduced to purely inorganic matter. A perfect reversal of this process of reduction would carry us from the inorganic to the organic; and such a reversal is at least conceivable. The tendency, indeed, of modern science is to break down the wall of partition between organic and inorganic, and to reduce both to the operation of forces which

are the same in kind, but which are differently compounded.

Consider the question of personal identity in relation to that of molecular form. Thirty-four years ago Mayer, of Heilbronn, with that power of genius which breathes large meanings into scanty facts, pointed out that the blood was "the oil of the lamp of life," the combustion of which sustains muscular action. The muscles are the machinery by which the dynamic power of the blood is brought into play. Thus the blood is consumed. But the whole body, though more slowly than the blood, wastes also, so that after a certain number of years it is entirely renewed. How is the sense of personal identity maintained across this flight of molecules? To man, as we know him, matter is necessary to consciousness; but the matter of any period may be all changed, while consciousness exhibits no solution of continuity. Like changing sentinels, the oxygen, hydrogen, and carbon that depart seem to whisper their secret to their comrades that arrive, and thus, while the Non-ego shifts, the Ego remains the same. Constancy of form in the grouping of the molecules, and not constancy of the molecules themselves, is the correlative of this constancy of perception. Life is a *wave* which in no two consecutive moments of its existence is composed of the same particles.

Supposing, then, the molecules of the human body, instead of replacing others, and thus renewing a pre-existing form, to be gathered first hand from nature and put together in the same relative positions as those which they occupy in the body. Supposing them to have the self-same forces and distribution of forces, the self-same motions and distribution of motions—would this organised concourse of molecules stand before us as a sentient thinking being? There seems no valid reason to believe that it would not. Or, supposing a planet carved from the sun, set spinning round an axis, and revolving round the sun at a distance from him equal to that of our earth, would one of the consequences of its refrigeration be the development of organic forms? I lean to the affirmative. *Structural* forces are certainly in the mass, whether or not those forces reach to the extent of forming a plant or an animal. In an amorphous drop of water lie latent all the marvels of crystalline force; and who will set limits to the possible play of molecules in a cooling planet? If these statements startle, it is because matter has been defined and maligned by philosophers and theologians who were equally unaware that it is, at bottom, essentially mystical and transcendental.

Questions such as these derive their present interest in great part from their audacity, which is sure, in due time, to disappear. And the sooner the public dread is abolished with reference to such questions the better for the cause of truth. As regards knowledge, physical science is polar. In one sense it knows, or is destined to know, everything. In another sense it knows nothing. Science understands much of this intermediate phase of things that we call nature, of which it is the product; but science knows nothing of the origin or destiny of nature. Who or what made the sun and gave his rays their alleged power? Who or what made and bestowed upon the ultimate particles of matter their wondrous power of varied interaction? Science does not know: the mystery, though pushed back, remains unaltered. To many of us who feel that there are more things in heaven and earth than are dreamt of in the present philosophy of science, but who have been also taught, by baffled efforts, how vain is the attempt to grapple with the Inscrutable, the ultimate frame of mind is that of Goethe:—

"Who dares to name His name,
Or belief in Him proclaim,
Veiled in mystery as He is, the All-enfolder?
Gleams across the mind His light,
Feels the lifted soul His might,
Dare it then deny His reign, the All-upholder?"

REFLECTIONS ON PRAYER AND NATURAL LAW

AMID the apparent confusion and caprice of natural phenomena, which roused emotions hostile to calm investigation, it must for ages have seemed hopeless to seek for law or orderly relation; and before the thought of law dawned upon the unfolding human mind these otherwise inexplicable effects were referred to personal agency. In the fall of a cataract the savage saw the leap of a spirit, and the echoed thunder-peal was to him the hammer-clang of an exasperated god. Propitiation of these terrible powers was the consequence, and sacrifice was offered to the demons of earth and air.

But observation tends to chasten the emotions and to check those structural efforts of the intellect which have emotion for their base. One by one natural phenomena came to be associated with their proximate causes; the idea of direct personal volition mixing itself with the economy of nature retreating more and more. Many of us fear this change. Our religious feelings are dear to us, and we look with suspicion and dislike on any philosophy the apparent tendency of which is to dry them up. Probably every change from ancient savagery to our present enlightenment has excited, in a greater or less degree, fears of this kind. But the fact is, that we have not yet determined whether its present form is necessary to the life and warmth of religious feeling. We may err in linking the imperishable with the transitory, and confound the living plant with the decaying pole to which it clings. My object, however, at present is not to argue, but to mark a tendency. We have ceased to propitiate the powers of nature—ceased even to pray for things in manifest contradiction to natural laws. In Protestant countries, at least, I think it is conceded that the age of miracles is past.

At an auberge near the foot of the Rhone glacier I met, in the summer of 1858, an athletic young priest, who, after a solid breakfast, including a bottle of wine, informed me that he had come up to "bless the mountains." This was the annual custom of the place. Year by year the Highest was entreated, by official intercessors, to make such meteorological arrangements as should ensure food and shelter for the flocks and herds of the Valaisians. A diversion of the Rhone, or a deepening of the river's bed, would, at the time I now mention, have been of incalculable benefit to the inhabitants of the valley. But the priest would have shrunk from the idea of asking the Omnipotent to open a new channel for the river, or to cause a portion of it to flow over the Grimsel pass, and down the valley of Oberhasli to Brientz. This he would have deemed a miracle, and he did not come to ask the Creator to perform miracles, but to do something which he manifestly thought lay quite within the bounds of the natural and non-miraculous. A Protestant gentleman who was present at the time smiled at this recital. He had no faith in the priest's blessing; still, he deemed his prayer different in kind from a request to open a new river-cut, or to cause the water to flow up-hill.

In a similar manner the same Protestant gentleman would doubtless smile at the honest Tyrolese priest who, when he feared the bursting of a glacier dam, offered the sacrifice of the Mass upon the ice as a means of averting the calamity. That poor man did not expect to convert the ice into adamant, or to strengthen its texture, so as to enable it

to withstand the pressure of the water; nor did he expect that his sacrifice would cause the stream to roll back upon its source and relieve him, by a miracle, of its presence. But beyond the boundaries of his knowledge lay a region where rain was generated, he knew not how. He was not so presumptuous as to expect a miracle, but he firmly believed that in yonder cloud-land matters could be so arranged, without trespass on the miraculous, that the stream which threatened him and his people should be caused to shrink within its proper bounds.

Both these priests fashioned that which they did not understand to their respective wants and wishes. In their case imagination came into play, uncontrolled by a knowledge of law. A similar state of mind was long prevalent among mechanicians. Many of these, among whom were to be reckoned men of consummate skill, were occupied a century ago with the question of perpetual motion. They aimed at constructing a machine which should execute work without the expenditure of power; and some of them went mad in the pursuit of this object. The faith in such a consummation, involving, as it did, immense personal profit to the inventor, was extremely exciting, and every attempt to destroy this faith was met by bitter resentment on the part of those who held it. Gradually, however, as men became more and more acquainted with the true functions of machinery, the dream dissolved. The hope of getting work out of mere mechanical combinations disappeared; but still there remained for the speculator a cloud-land denser than that which filled the imagination of the Tyrolese priest, and out of which he still hoped to evolve perpetual motion. There was the mystic store of chemic force, which nobody understood; there were heat and light, electricity and magnetism, all competent to produce mechanical motion.[1] Here, then, was the mine in which our gem must be sought. A modified and more refined form of the ancient faith revived; and, for aught I know, a remnant of sanguine designers may at the present moment be engaged on the problem which like-minded men in former ages left unsolved.

And why should a perpetual motion, even under modern conditions, be impossible? The answer to this question is the statement of that great generalisation of modern science which is known under the name of the Conservation of Energy. This principle asserts that no power can make its appearance in nature without an equivalent expenditure of some other power; that natural agents are so related to each other as to be mutually convertible, but that no new agency is created. Light runs into heat; heat into electricity; electricity into magnetism; magnetism into mechanical force; and mechanical force again into light and heat. The Proteus changes, but he is ever the same; and his changes in nature, supposing no miracle to supervene, are the expression, not of spontaneity, but of physical necessity. A perpetual motion, then, is deemed impossible because it demands the creation of energy, whereas the principle of Conservation is—no creation, but infinite conversion.

It is an old remark that the law which moulds a tear also rounds a planet. In the application of law in nature the terms "great" and "small" are unknown. Thus the principle referred to teaches us that the Italian wind, gliding over the crest of the Matterhorn, is as firmly ruled as the earth in its orbital revolution round the sun; and that the fall of its vapour into clouds is exactly as much a matter of necessity as the return of the seasons. The dispersion, therefore, of the slightest mist by the special volition of the Eternal would be as much a miracle as the rolling of the Rhone over the Grimsel precipices, down the valley of Hasli to Meyringen and Brientz.

It seems to me quite beyond the

[1] See Helmholtz, *Wechselwirkung der Naturkräfte.*

present power of science to demonstrate that the Tyrolese priest, or his colleague of the Rhone valley, asked for an "impossibility" in praying for good weather; but Science *can* demonstrate the incompleteness of the knowledge of nature which limited their prayers to this narrow ground; and she may lessen the number of instances in which we "ask amiss" by showing that we sometimes pray for the performance of a miracle when we do not intend it. She does assert, for example, that without a disturbance of natural law, quite as serious as the stoppage of an eclipse or the rolling of the river Niagara up the Falls, no act of humiliation, individual or national, could call one shower from heaven or deflect towards us a single beam of the sun.

Those, therefore, who believe that the miraculous is still active in nature may, with perfect consistency, join in our periodic prayers for fair weather and for rain; while those who hold that the age of miracles is past will, if they be consistent, refuse to join in these petitions. And these latter, if they wish to fall back upon such a justification, may fairly urge that the latest conclusions of science are in perfect accordance with the doctrine of the Master himself, which manifestly was that the distribution of natural phenomena is not affected by moral or religious causes. "He maketh His sun to rise on the evil and on the good, and sendeth rain on the just and on the unjust." Granting "the power of Free Will in man," so strongly claimed by Professor Mansel in his admirable defence of the belief in miracles, and assuming the efficacy of free prayer to produce changes in external nature, it necessarily follows that natural laws are more or less at the mercy of man's volition, and no conclusion founded on the assumed permanence of those laws would be worthy of confidence.

It is a wholesome sign for England that she numbers among her clergy men wise enough to understand all this, and courageous enough to act up to their knowledge. Such men do service to public character by encouraging a manly and intelligent conflict with the real causes of disease and scarcity, instead of a delusive reliance on supernatural aid. But they have also a value beyond this local and temporary one. They prepare the public mind for changes which, though inevitable, could hardly, without such preparation, be wrought without violence. Iron is strong; still, water in crystallising will shiver an iron envelope, and the more unyielding the metal is the worse for its safety. There are in the world men who would encompass philosophic speculation by a rigid envelope, hoping thereby to restrain it, but in reality giving it explosive force. In England, thanks to men of the stamp to which I have alluded, scope is gradually given to thought for changes of aggregation, and the envelope slowly alters its form, in accordance with the necessities of the time.

The proximate origin of the foregoing slight article, and probably the remoter origin of the next following one, was this. Some years ago a day of prayer and humiliation, on account of a bad harvest, was appointed by the proper religious authorities; but certain clergymen of the Church of England, doubting the wisdom of the demonstration, declined to join in the services of the day. For this act of nonconformity they were severely censured by some of their brethren. Rightly or wrongly, my sympathies were on the side of these men; and, to lend them a helping hand in their struggle against odds, I inserted the foregoing chapter in a little book entitled *Mountaineering in 1861*. Some time subsequently I received from a gentleman of great weight and distinction in the scientific world, and, I believe, of perfect orthodoxy in the religious one, a note directing my attention to an exceedingly thoughtful article on Prayer and Cholera in the *Pall Mall Gazette*. My eminent correspondent deemed the article a fair answer to the remarks made by me in 1861. I, also, was struck by the temper and ability of the article; but I could not deem its arguments satisfactory, and in a short note to the editor of the *Pall Mall Gazette* I ventured to state so much. The letter elicited some very able replies, and a second leading article was also devoted to the subject. In answer to all, I risked the publication of a second letter, and soon afterwards, by an extremely courteous note from the editor, the discussion was closed.

Though thus stopped locally, the discussion flowed in other directions. Sermons were

preached, essays were published, articles were written, while a copious correspondence occupied the pages of some of the religious newspapers. It gave me sincere pleasure to notice that the discussion, save in a few cases where natural coarseness had the upper hand, was conducted with a minimum of vituperation. The severity shown was hardly more than sufficient to demonstrate earnestness, while gentlemanly feeling was too predominant to permit that earnestness to contract itself to bigotry or to clothe itself in abuse. It was probably the memory of this discussion which caused another excellent friend of mine to recommend to my perusal the exceedingly able work which in the next article I have endeavoured to review.

MIRACLES AND SPECIAL PROVIDENCES[1]

1867

It is my privilege to enjoy the friendship of a select number of religious men, with whom I converse freely upon theological subjects, expressing without disguise the notions and opinions I entertain regarding their tenets, and hearing in return these notions and opinions subjected to criticism. I have thus far found them liberal and loving men, patient in hearing, tolerant in reply, who know how to reconcile the duties of courtesy with the earnestness of debate. From one of these, nearly a year ago, I received a note, recommending strongly to my attention the volume of *Bampton Lectures* for 1865, in which the question of miracles is treated by Mr. Mozley. Previous to receiving this note, I had in part made the acquaintance of the work through an able and elaborate review of it in the *Times*. The combined effect of the letter and the review was to make the book the companion of my summer tour in the Alps. There, during the wet and snowy days which were only too prevalent in 1866, and during the days of rest interpolated between days of toil, I made myself more thoroughly conversant with Mr. Mozley's volume. I found it clear and strong—an intellectual tonic, as bracing and pleasant to my mind as the keen air of the mountains was to my body. From time to time I jotted down thoughts regarding it, intending afterwards to work them up into a coherent whole. Other duties, however, interfered with the complete carrying out of this intention, and what I wrote last summer I now publish, not hoping to be able, within any reasonable time, to render my defence of scientific method more complete.

Mr. Mozley refers at the outset of his task to the movement against miracles which of late years has taken place, and which determined his choice of a subject. He acquits modern science of having had any great share in the production of this movement. The objection against miracles, he says, does not arise from any minute knowledge of the law of nature, but simply because they are opposed to that plain and obvious order of nature which everybody sees. The present movement is, he thinks, to be ascribed to the greater earnestness and penetration of the present age. Formerly miracles were accepted without question, because without reflection; but the exercise of the "historic imagination" is a characteristic of our own time. Men are now accustomed to place before themselves vivid images of historic facts; and when a miracle rises to view, they halt before the astounding occurrence, and, realising it with the same clearness

[1] *Fortnightly Review*, New Series, vol. i., p. 645.

as if it were now passing before their eyes, they ask themselves, "Can this have taken place?" In some instances the effort to answer this question has led to a disbelief in miracles, in others to a strengthening of belief. The aim of Mr. Mozley's lectures is to show that the strengthening of belief is the logical result which ought to follow from the examination of the facts.

Attempts have been made by religious men to bring the Scripture miracles within the scope of the order of nature, but all such attempts are rejected by Mr. Mozley as utterly futile and wide of the mark. Regarding miracles as a necessary accompaniment of a revelation, their evidential value in his eyes depends entirely upon their deviation from the order of nature. Thus deviating, they suggest and illustrate a power higher than nature, a "personal will"; and they commend the person in whom this power is vested as a messenger from on high. Without these credentials such a messenger would have no right to demand belief, even were his assertions regarding his Divine mission backed by a holy life. Nor is it by miracles alone that the order of nature is, or may be, disturbed. The material universe is also the arena of "special providences." Under these two heads Mr. Mozley distributes the total preternatural. One form of the preternatural may shade into the other, as one colour passes into another in the rainbow; but while the line which divides the specially providential from the miraculous cannot be sharply drawn, their distinction broadly expressed is this: that, while a special providence can only excite surmise more or less probable, it is "the nature of a miracle to give proof, as distinguished from mere surmise, of Divine design."

Mr. Mozley adduces various illustrations of what he regards to be special providences as distinguished from miracles. "The death of Arius," he says, "was not miraculous, because the coincidence of the death of a heresiarch taking place when it was peculiarly advantageous to the orthodox faith...... was not such as to compel the inference of extraordinary Divine agency; but it was a special providence, because it carried a reasonable appearance of it. The miracle of the Thundering Legion was a special providence, but not a miracle, for the same reason, because the coincidence of an instantaneous fall of rain, in answer to prayer, carried some appearance, but not proof, of preternatural agency." The eminent lecturer's remarks on this head brought to my recollection certain narratives published in Methodist magazines, which I used to read with avidity when a boy. The general title of these exciting stories, if I remember right, was "The Providence of God Asserted," and in them the most extraordinary escapes from peril were recounted and ascribed to prayer, while equally wonderful instances of calamity were adduced as illustrations of Divine retribution. In such magazines, or elsewhere, I found recorded the case of the celebrated Samuel Hick, which, as it illustrates a whole class of special providences approaching in conclusiveness to miracles, is worthy of mention here. It is related of this holy man that, on one occasion, flour was lacking to make the sacramental bread. Grain was present, and a windmill was present, but there was no wind to grind the corn. With faith undoubting, Samuel Hick prayed to the Lord of the winds: the sails turned, the corn was ground, after which the wind ceased. According to the canon of the Bampton Lecturer, this, though carrying a strong appearance of an immediate exertion of Divine energy, lacks by a hair's-breadth the quality of a miracle. For the wind *might* have arisen, and *might* have ceased, in the ordinary course of nature. Hence the occurrence did not "compel the inference of extraordinary Divine agency." In like manner Mr. Mozley considers that "the appearance of the cross to Constantine was a miracle, or a special providence, according to what account of it we adopt. As

only a meteoric appearance in the shape of a cross, it gave some token of preternatural agency, but not full evidence."

In the Catholic canton of Switzerland where I now write, and still more among the pious Tyrolese, the mountains are dotted with shrines, containing offerings of all kinds, in acknowledgment of special mercies—legs, feet, arms, and hands—of gold, silver, brass, and wood, according as worldly possessions enabled the grateful heart to express its indebtedness. Most of these offerings are made to the Virgin Mary. They are recognitions of "special providences," wrought through the instrumentality of the Mother of God. Mr. Mozley's belief, that of the Methodist chronicler, and that of the Tyrolese peasant, are substantially the same. Each of them assumes that nature, instead of flowing ever onward in the uninterrupted rhythm of cause and effect, is mediately ruled by the free human will. As regards *direct* action upon natural phenomena, man's wish and will, as expressed in prayer, are confessedly powerless; but prayer is the trigger which liberates the Divine power, and to this extent, if the will be free, man, of course, commands nature.

Did the existence of this belief depend solely upon the material benefits derived from it, it could not, in my opinion, last a decade. As a purely objective fact, we should soon see that the distribution of natural phenomena is unaffected by the merits or the demerits of men; that the law of gravitation crushes the simple worshippers of Ottery St. Mary, while singing their hymns, just as surely as if they were engaged in a midnight brawl. The hold of this belief upon the human mind is not due to outward verification, but to the inner warmth, force, and elevation with which it is commonly associated. It is plain, however, that these feelings may exist under the most various forms. They are not limited to Church of England Protestantism—they are not even limited to Christianity. Though less refined, they are certainly not less strong in the heart of the Methodist and the Tyrolese peasant than in the heart of Mr. Mozley. Indeed, those feelings belong to the primal powers of man's nature. A "sceptic" may have them. They find vent in the battle-cry of the Moslem. They take hue and form in the hunting-grounds of the Red Indian; and raise all of them, as they raise the Christian, upon a wave of victory, above the terrors of the grave.

The character then of a miracle, as distinguished from a special providence, is that the former furnishes *proof*, while in the case of the latter we have only surmise. Dissolve the element of doubt, and the alleged fact passes from the one class of the preternatural into the other. In other words, if a special providence could be proved to be a special providence, it would cease to be a special providence and become a miracle. There is not the least cloudiness about Mr. Mozley's meaning here. A special providence is a doubtful miracle. Why, then, not call it so? The term employed by Mr. Mozley conveys no negative suggestion, whereas the negation of certainty is the peculiar characteristic of the thing intended to be expressed. There is an apparent unwillingness on the part of the lecturer to call a special providence what his own definition makes it to be. Instead of speaking of it as a doubtful miracle, he calls it "an invisible miracle." He speaks of the point of contact of supernatural power with the chain of causation being so high up as to be wholly, or in part, out of sight, whereas the essence of a special providence is the uncertainty whether there is any contact at all, either high or low. By the use of an incorrect term, however, a grave danger is avoided. For the idea of doubt, if kept systematically before the mind, would soon be fatal to the special providence, considered as a means of edification. The term employed, on the contrary, invites and encourages the trust which is necessary to supplement the evidence.

This inner trust, though at first rejected by Mr. Mozley in favour of external proof,

is subsequently called upon to do momentous duty in regard to miracles. Whenever the evidence of the miraculous seems incommensurate with the fact which it has to establish, or rather when the fact is so amazing that hardly any evidence is sufficient to establish it, Mr. Mozley invokes "the affections." They must urge the reason to accept the conclusion, from which unaided it recoils. The affections and emotions are eminently the court of appeal in matters of real religion, which is an affair of the heart; but they are not, I submit, the court in which to weigh allegations regarding the credibility of physical facts. These must be judged by the dry light of the intellect alone, appeals to the affections being reserved for cases where moral elevation, and not historic conviction, is the aim. It is, moreover, because the result, in the case under consideration, is deemed desirable that the affections are called upon to back it. If undesirable, they would, with equal right, be called upon to act the other way. Even to the disciplined scientific mind this would be a dangerous doctrine. A favourite theory—the desire to establish or avoid a certain result—can so warp the mind as to destroy its powers of estimating facts. I have known men to work for years under a fascination of this kind, unable to extricate themselves from its fatal influence. They had certain data, but not, as it happened, enough. By a process exactly analogous to that invoked by Mr. Mozley, they supplemented the data, and went wrong. From that hour their intellects were so blinded to the perception of adverse phenomena that they never reached truth. If, then, to the disciplined scientific mind this incongruous mixture of proof and trust be fraught with danger, what must it be to the indiscriminate audience which Mr. Mozley addresses? In calling upon this agency he acts the part of Frankenstein. It is a monster thus evoked that we see stalking abroad in the degrading spiritualistic phenomena of the present day. Again, I say, where the aim is to elevate the mind, to quicken the moral sense, to kindle the fire of religion in the soul, let the affections by all means be invoked; but they must not be permitted to colour our reports, or to influence our acceptance of reports, of occurrences in external nature. Testimony as to natural facts is worthless when wrapped in this atmosphere of the affections, the most earnest subjective truth being thus rendered perfectly compatible with the most astounding objective error.

There are questions in judging of which the affections or sympathies are often our best guides, the estimation of moral goodness being one of these. But at this precise point, where they are really of use, Mr. Mozley excludes the affections and demands a miracle as a certificate of character. He will not accept any other evidence of the perfect goodness of Christ. "No outward life and conduct," he says, "however irreproachable, could prove His perfect sinlessness, because goodness depends upon the inward motive, and the perfection of the inward motive is not proved by the outward act." But surely the miracle is an outward act, and to pass from it to the inner motive imposes a greater strain upon logic than that involved in our ordinary methods of estimating men. There is, at least, moral congruity between the outward goodness and the inner life, but there is no such congruity between the miracle and the life within. The test of moral goodness laid down by Mr. Mozley is not the test of John, who says: "He that doeth righteousness is righteous"; nor is it the test of Jesus: "By their fruits ye shall know them; do men gather grapes of thorns, or figs of thistles?" But it *is* the test of another: "If thou be the Son of God, command that these stones be made bread." For my own part, I prefer the attitude of Fichte to that of Mr. Mozley. "The Jesus of John," says this noble and mighty thinker, "knows no other God than the true God, in whom we all are, and live, and may be blessed, and out of

whom there is only death and nothingness. And," continues Fichte, "he appeals, and rightly appeals, in support of this truth, not to reasoning, but to the inward practical sense of truth in man, not even knowing any other proof than this inward testimony: 'If any man will do the will of Him who sent Me, he shall know of the doctrine whether it be of God.'"

Accepting Mr. Mozley's test, with which alone I am now dealing, it is evident that, in the demonstration of moral goodness, the *quantity* of the miraculous comes into play. Had Christ, for example, limited himself to the conversion of water into wine, He would have fallen short of the performance of Jannes and Jambres; for it is a smaller thing to convert one liquid into another than to convert a dead rod into a living serpent. But Jannes and Jambres, we are informed, were not good. Hence, if Mr. Mozley's test be a true one, a point must exist on the one side of which miraculous power demonstrates goodness, while on the other side it does not. How is this "point of contrary flexure" to be determined? It must lie somewhere between the magicians and Moses, for within this space the power passed from the diabolical to the Divine. But how to mark the point of passage—how, out of a purely *quantitative* difference in the visible manifestation of power, we are to infer a total inversion of quality—it is extremely difficult to see. Moses, we are informed, produced a large reptile; Jannes and Jambres produced a small one. I do not possess the intellectual faculty which would enable me to infer, from those data, either the goodness of the one or the badness of the other; and in the highest recorded manifestations of the miraculous I am equally at a loss. Let us not play fast and loose with the miraculous; either it is a demonstration of goodness in all cases or in none. If Mr. Mozley accepts Christ's goodness as transcendent because He did such works as no other man did, he ought, logically speaking, to accept the works of those who, in His name, had cast out devils, as demonstrating a proportionate goodness on their part. But it is people of this class who are consigned to everlasting fire prepared for the devil and his angels. Such zeal as that of Mr. Mozley for miracles tends, I fear, to eat his religion up. The logical threatens to stifle the spiritual. The truly religious soul needs no miraculous proof of the goodness of Christ. The words addressed to Matthew at the receipt of custom required no miracle to produce obedience. It was by no stroke of the supernatural that Jesus caused those sent to seize Him to go backward and fall to the ground. It was the sublime and holy effluence from within, which needed no prodigy to commend it to the reverence even of his foes.

As regards the function of miracles in the founding of a religion, Mr. Mozley institutes a comparison between the religion of Christ and that of Mohammed; and he derides the latter as "irrational" because it does not profess to adduce miracles in proof of its supernatural origin. But the religion of Mohammed, notwithstanding this drawback, has thriven in the world, and at one time it held sway over larger populations than Christianity itself. The spread and influence of Christianity are, however, brought forward by Mr. Mozley as "a permanent, enormous, and incalculable practical result" of Christian miracles; and he makes use of this result to strengthen his plea for the miraculous. His logical warrant for this proceeding is not clear. It is the method of science, when a phenomenon presents itself towards the production of which several elements may contribute, to exclude them one by one, so as to arrive at length at the truly effective cause. Heat, for example, is associated with a phenomenon; we exclude heat, but the phenomenon remains: hence, heat is not its cause. Magnetism is associated with a phenomenon; we exclude magnetism, but the phenomenon remains: hence, magnetism

is not its cause. Thus, also, when we seek the cause of the diffusion of a religion —whether it be due to miracles or to the spiritual force of its founders—we exclude the miracles, and, finding the result unchanged, we infer that miracles are not the effective cause. This important experiment Mohammedanism has made for us. It has lived and spread without miracles; and to assert, in the face of this, that Christianity has spread *because* of miracles is, I submit, opposed both to the spirit of science and the common sense of mankind.

The incongruity of inferring moral goodness from miraculous power has been dwelt upon above; in another particular also the strain put by Mr. Mozley upon miracles is, I think, more than they can bear. In consistency with his principles, it is difficult to see how he is to draw from the miracles of Christ any certain conclusion as to His Divine nature. He dwells very forcibly on what he calls "the argument from experience," in the demolition of which he takes obvious delight. He destroys the argument, and repeats it, for the mere pleasure of again and again knocking the breath out of it. Experience, he urges, can only deal with the past; and the moment we attempt to project experience a hair's-breadth beyond the point it has at any moment reached we are condemned by reason. It appears to me that, when he infers from Christ's miracles a Divine and altogether superhuman energy, Mr. Mozley places himself precisely under this condemnation. For what is his logical ground for concluding that the miracles of the New Testament illustrate Divine power? May they not be the result of expanded human power? A miracle he defines as something impossible to man. But how does he know that the miracles of the New Testament are impossible to man? Seek as he may, he has absolutely no reason to adduce save this—that man has never hitherto accomplished such things. But does the fact that man has never raised the dead prove that he can never raise the dead? "Assuredly not," must be Mr. Mozley's reply; "for this would be pushing experience beyond the limit it has now reached—which I pronounce unlawful." Then a period may come when man will be able to raise the dead. If this be conceded—and I do not see how Mr. Mozley can avoid the concession—it destroys the necessity of inferring Christ's Divinity from His miracles. He, it may be contended, antedated the humanity of the future; as a mighty tidal wave leaves high upon the beach a mark which by-and-by becomes the general level of the ocean. Turn the matter as you will, no other warrant will be found for the all-important conclusion that Christ's miracles demonstrate Divine power than an argument which has been stigmatised by Mr. Mozley as a "rope of sand"—the argument from experience.

The learned Bampton Lecturer would be in this position, even had he seen with his own eyes every miracle recorded in the New Testament. But he has *not* seen these miracles; and his intellectual plight is, therefore, worse. He accepts these miracles on testimony. Why does he believe that testimony? How does he know that it is not delusion; how is he sure that it is not even fraud? He will answer that the writing bears the marks of sobriety and truth; and that in many cases the bearers of this message to mankind sealed it with their blood. Granted with all my heart; but whence the value of all this? Is it not solely derived from the fact that men, *as we know them*, do not sacrifice their lives in the attestation of that which they know to be untrue? Does not the entire value of the testimony of the Apostles depend ultimately upon our experience of human nature? It appears, then, that those said to have seen the miracles based their inferences from what they saw on the argument from experience, and that Mr. Mozley bases his belief in their testimony on the same argument. The weakness of his conclusion is quadrupled by this double insertion of a principle of belief to which he flatly denies rationality. His

reasoning, in fact, cuts two ways—if it destroys our trust in the order of nature, it far more effectually abolishes the basis on which Mr. Mozley seeks to found the Christian religion.

Over this argument from experience, which at bottom is *his* argument, Mr. Mozley rides rough-shod. There is a dash of scorn in the energy with which he tramples on it. Probably some previous writer had made too much of it, and thus invited his powerful assault. Finding the difficulty of belief in miracles to rise from their being in contradiction to the order of nature, he sets himself to examine the grounds of our belief in that order. With a vigour of logic rarely equalled, and with a confidence in its conclusions never surpassed, he disposes of this belief in a manner calculated to startle those who, without due examination, had come to the conclusion that the order of nature was secure.

What we mean, he says, by our belief in the order of nature is the belief that the future will be like the past. There is not, according to Mr. Mozley, the slightest rational basis for this belief :—

That any cause in nature is more permanent than its existing and known effects, extending further, and about to produce other and more instances besides what it has produced already, we have no evidence. Let us imagine [he continues] the occurrence of a particular physical phenomenon for the first time. Upon that single occurrence we should have but the very faintest expectation of another. If it did occur again, once or twice, so far from counting on another occurrence, a cessation would occur as the most natural event to us. But let it continue one hundred times, and we should find no hesitation in inviting persons from a distance to see it ; and if it occurred every day for years, its occurrence would be a certainty to us, its cessation a marvel. ....What ground of reason can we assign for an expectation that any part of the course of nature will be the next moment what it has been up to this moment—*i.e.*, for our belief in the uniformity of nature? None. No demonstrative reason can be given, for the contrary to the recurrence of a fact of nature is no contradiction. No probable reason can be given; for all probable reasoning respecting the course of nature is founded *upon* this presumption of likeness, and therefore cannot be the foundation of it. No reason can be given for this belief. It is without a reason. It rests upon no rational grounds, and can be traced to no rational principle.

"Everything," Mr. Mozley, however, adds, "depends upon this belief; every provision we make for the future, every safeguard and caution we employ against it, all calculation, all adjustment of means to ends, supposes this belief; and yet this belief has no more producible reason for it than a speculation of fancy.......It is necessary, all-important for the purposes of life, but solely practical, and possesses no intellectual character....... The proper function," continues Mr. Mozley, "of the inductive principle, the argument from experience, the belief in the order of nature—by whatever phrase we designate the same instinct—is to operate as a practical basis for the affairs of life and the carrying on of human society." To sum up, the belief in the order of nature is general, but it is "an unintelligent impulse, of which we can give no rational account." It is inserted into our constitution solely to induce us to till our fields, to raise our winter fuel, and thus to meet the future on the perfectly gratuitous supposition that it will be like the past.

"Thus, step by step," says Mr. Mozley, with the emphasis of a man who feels his position to be a strong one, "has philosophy loosened the connection of the order of nature with the ground of reason, befriending in exact proportion as it has done this the principle of miracles." For "this belief not having itself a foundation in reason, the ground is gone upon which it could be maintained that miracles, as opposed to the order of nature, are opposed to reason." When we regard this belief in connection with science, "in which connection it receives a more imposing name, and is called the inductive principle," the result is the same. "The inductive principle is only this unreasoning impulse applied to a scientifically ascertained fact.......Science has led up to the fact; but there it stops, and for converting this fact into a law a totally unscientific principle comes into play, the same as

that which generalises the commonest observation of nature."

The eloquent pleader of the cause of miracles passes over without a word the *results* of scientific investigation, as proving anything rational regarding the principles or method by which such results have been achieved. Here, as elsewhere, he declines the test: "By their fruits shall ye know them." Perhaps our best way of proceeding will be to give one or two examples of the mode in which men of science apply the unintelligent impulse with which Mr. Mozley credits them, and which shall show, by illustration, the surreptitious method whereby they climb from the region of facts to that of laws.

Before the sixteenth century it was known that water rises in a pump, the effect being then explained by the maxim that "Nature abhors a vacuum." It was not known that there was any limit to the height to which the water would ascend, until, on one occasion, the gardeners of Florence, while attempting to raise water to a very great elevation, found that the column ceased at a height of thirty-two feet. Beyond this all the skill of the pump-maker could not get it to rise. The fact was brought to the notice of Galileo, and he, soured by a world which had not treated his science over kindly, is said to have twitted the philosophy of the time by remarking that nature evidently abhorred a vacuum only to a height of thirty-two feet. Galileo, however, did not solve the problem. It was taken up by his pupil Torricelli, to whom, after due pondering, the thought occurred that the water might be forced into the tube by a pressure applied to the surface of the liquid outside. But where, under the actual circumstances, was such a pressure to be found? After much reflection, it flashed upon Torricelli that the atmosphere might possibly exert this pressure; that the impalpable air might possess weight; and that a column of water thirty-two feet high might be of the exact weight necessary to hold the pressure of the atmosphere in equilibrium.

There is much in this process of pondering and its results which it is impossible to analyse. It is by a kind of inspiration that we rise from the wise and sedulous contemplation of facts to the principles on which they depend. The mind is, as it were, a photographic plate, which is gradually cleansed by the effort to think rightly, and which, when so cleansed, and not before, receives impressions from the light of truth. This passage from facts to principles is called induction; and induction, in its highest form, is, as I have just stated, a kind of inspiration. But, to make it sure, the inward sight must be shown to be in accordance with outward fact. To prove or disprove the induction, we must resort to deduction and experiment.

Torricelli reasoned thus: If a column of water thirty-two feet high holds the pressure of the atmosphere in equilibrium, a shorter column of a heavier liquid ought to do the same. Now, mercury is thirteen times heavier than water; hence, if my induction be correct, the atmosphere ought to be able to sustain only thirty inches of mercury. Here, then, is a deduction which can be immediately submitted to experiment. Torricelli took a glass tube a yard or so in length, closed at one end and open at the other, and, filling it with mercury, he stopped the open end with his thumb, and inverted it into a basin filled with the liquid metal. One can imagine the feeling with which Torricelli removed his thumb, and the delight he experienced on finding that his thought had forestalled a fact never before revealed to human eyes. The column sank, but it ceased to sink at a height of thirty inches, leaving the Torricellian vacuum over head. From that hour the theory of the pump was established.

The celebrated Pascal followed Torricelli with another deduction. He reasoned thus: If the mercurial column be supported by the atmosphere, the higher we ascend in the air, the lower

the column ought to sink, for the less will be the weight of the air over head. He caused a friend to ascend the Puy de Dôme, carrying with him a barometric column; and it was found that during the ascent the column sank, and that during the subsequent descent the column rose.

Between the time here referred to and the present, *millions* of experiments have been made upon this subject. Every village pump is an apparatus for such experiments. In thousands of instances, moreover, pumps have refused to work; but on examination it has infallibly been found that the well was dry, that the pump required priming, or that some other defect in the apparatus accounted for the anomalous action. In every case of the kind the skill of the pump-maker has been found to be the true remedy. In no case has the pressure of the atmosphere ceased; constancy, as regards the lifting of pump-water, has been hitherto the demonstrated rule of nature. So also as regards Pascal's experiment. His experience has been the universal experience ever since. Men have climbed mountains, and gone up in balloons; but no deviation from Pascal's result has ever been observed. Barometers, like pumps, have refused to act; but instead of indicating any suspension of the operations of nature, or any interference on the part of its author with atmospheric pressure, examination has in every instance fixed the anomaly upon the instruments themselves. It is this welding, then, of rigid logic to verifying fact that Mr. Mozley refers to an "unreasoning impulse."

Let us now briefly consider the case of Newton. Before his time men had occupied themselves with the problem of the solar system. Kepler had deduced, from a vast mass of observations, those general expressions of planetary motion known as "Kepler's laws." It had been observed that a magnet attracts iron; and by one of those flashes of inspiration which reveal to the human mind the vast in the minute, the general in the particular, it had been inferred that the force by which bodies fall to the earth might also be an attraction. Newton pondered all these things. He looked, as was his wont, into the darkness until it became entirely luminous. How this light arises we cannot explain; but, as a matter of fact, it does arise. Let me remark here, that this kind of pondering is a process with which the ancients could have been but imperfectly acquainted. They, for the most part, found the exercise of fantasy more pleasant than careful observation and subsequent brooding over facts. Hence it is that, when those whose education has been derived from the ancients speak of "the reason of man," they are apt to omit from their conception of reason one of its most important factors. Well, Newton slowly marshalled his thoughts, or, rather, they came to him while he "intended his mind," rising like a series of intellectual births out of chaos. He made this idea of attraction his own. But, to apply the idea to the solar system, it was necessary to know the magnitude of the attraction, and the law of its variation with the distance. His conceptions first of all passed from the action of the earth as a whole to that of its constituent particles. And persistent thought brought more and more clearly out the final conclusion, that every particle of matter attracts every other particle with a force varying inversely as the square of the distance between the particles.

Here we have the flower and outcome of Newton's induction; and how to verify it, or to disprove it, was the next question. The first step of the philosopher in this direction was to prove, mathematically, that if this law of attraction be the true one, if the earth be constituted of particles which obey this law, then the action of a sphere equal to the earth in size on a body outside of it is the same as that which would be exerted if the whole mass of the sphere were contracted to a point at its centre. Practically speaking, then, the centre of the

earth is the point from which distances must be measured to bodies attracted by the earth.

From experiments executed before his time, Newton knew the amount of the earth's attraction at the earth's surface, or at a distance of 4,000 miles from its centre. His object now was to measure the attraction at a greater distance, and thus to determine the law of its diminution. But how was he to find a body at a sufficient distance? He had no balloon, and, even if he had, he knew that any height to which he could attain would be too small to enable him to solve his problem. What did he do? He fixed his thoughts upon the moon, a body 240,000 miles, or sixty times the earth's radius, from the earth's centre. He virtually weighed the moon, and found that weight to be $\frac{1}{3600}$th of what it would be at the earth's surface. This is exactly what his theory required. I will not dwell here upon the pause of Newton after his first calculations, or speak of his self-denial in withholding them because they did not quite agree with the observations then at his command. Newton's action in this matter is the normal action of the scientific mind. If it were otherwise—if scientific men were not accustomed to demand verification—if they were satisfied with the imperfect while the perfect is attainable, their science, instead of being, as it is, a fortress of adamant, would be a house of clay, ill-fitted to bear the buffetings of the theologic storms to which it is periodically exposed.

Thus we see that Newton, like Torricelli, first pondered his facts, illuminated them with persistent thought, and finally divined the character of the force of gravitation. But, having thus travelled inward to the principle, he reversed his steps, carried the principle outwards, and justified it by demonstrating its fitness to external nature.

And here, in passing, I would notice a point which is well worthy of attention. Kepler had deduced his laws from observation. As far back as those observations extended, the planetary motions had obeyed these laws; and neither Kepler nor Newton entertained a doubt as to their continuing to obey them. Year after year, as the ages rolled, they believed that those laws would continue to illustrate themselves in the heavens. But this was not sufficient. The scientific mind can find no repose in the mere registration of sequence in nature. The further question intrudes itself with resistless might, Whence comes the sequence? What is it that binds the consequent to its antecedent in nature? The truly scientific intellect never can attain rest until it reaches the *forces* by which the observed succession is produced. It was thus with Torricelli; it was thus with Newton; it is thus preeminently with the scientific man of to-day. In common with the most ignorant, he shares the belief that spring will succeed winter, that summer will succeed spring, that autumn will succeed summer, and that winter will succeed autumn.* But he knows still further—and this knowledge is essential to his intellectual repose—that this succession, besides being permanent, is, under the circumstances, *necessary*; that the gravitating force exerted between the sun and a revolving sphere with an axis inclined to the plane of its orbit must produce the observed succession of the seasons. Not until this relation between forces and phenomena has been established is the law of reason rendered concentric with the law of nature; and not until this is effected does the mind of the scientific philosopher rest in peace.

The expectation of likeness, then, in the procession of phenomena is not that on which the scientific mind founds its belief in the order of nature. If the force be permanent, the phenomena are necessary, whether they resemble or do not resemble anything that has gone before. Hence, in judging of the order of nature, our inquiries eventually relate to the permanence of force. From Galileo to Newton, from Newton to our own time, eager eyes have been scanning

the heavens, and clear heads have been pondering the phenomena of the solar system. The same eyes and minds have been also observing, experimenting, and reflecting on the action of gravity at the surface of the earth. Nothing has occurred to indicate that the operation of the law has for a moment been suspended; nothing has ever intimated that nature has been crossed by spontaneous action, or that a state of things at any time existed which could not be rigorously deduced from the preceding state.

Given the distribution of matter, and the forces in operation, in the time of Galileo, the competent mathematician of that day could predict what is now occurring in our own. We calculate eclipses in advance, and find our calculations true to the second. We determine the dates of those that have occurred in the early times of history, and find calculation and history in harmony. Anomalies and perturbations in the planets have been over and over again observed; but these, instead of demonstrating any inconstancy on the part of natural law, have invariably been reduced to consequences of that law. Instead of referring the perturbations of Uranus to any interference on the part of the author of nature with the law of gravitation, the question which the astronomer proposed to himself was: "How, in accordance with this law, can the perturbation be produced?" Guided by a principle, he was enabled to fix the point of space in which, if a mass of matter were placed, the observed perturbations would follow. We know the result. The practical astronomer turned his telescope towards the region which the intellect of the theoretic astronomer had already explored, and the planet now named Neptune was found in its predicted place. A very respectable outcome, it will be admitted, of an impulse which "rests upon no rational grounds, and can be traced to no rational principle," which possesses "no intellectual character," which "philosophy" has uprooted from "the ground of reason," and fixed in that "large irrational department" discovered for it, by Mr. Mozley, in the hitherto unexplored wilderness of the human mind.

The proper function of the inductive principle, or the belief in the order of nature, says Mr. Mozley, is "to act as a practical basis for the affairs of life and the carrying on of human society." But what, it may be asked, has the planet Neptune, or the belts of Jupiter, or the whiteness about the poles of Mars, to do with the affairs of society? How is society affected by the fact that the sun's atmosphere contains sodium, or that the nebula of Orion contains hydrogen gas? Nineteen-twentieths of the force employed in the exercise of the inductive principle, which, reiterates Mr. Mozley, is "purely practical," have been expended upon subjects as unpractical as these. What practical interest has society in the fact that the spots on the sun have a decennial period, and that, when a magnet is closely watched for half a century, it is found to perform small motions which synchronise with the appearance and disappearance of the solar spots? And yet, I doubt not, Sir Edward Sabine would deem a life of intellectual toil amply rewarded by being privileged to solve, at its close, these infinitesimal motions.

The inductive principle is founded in man's desire to know—a desire arising from his position among phenomena which are reducible to order by his intellect. The material universe is the complement of the intellect; and, without the study of its laws, reason could never have awakened to the higher forms of self-consciousness at all. It is the Non-ego through and by which the Ego is endowed with self-discernment. We hold it to be an exercise of reason to explore the meaning of a universe to which we stand in this relation, and the work we have accomplished is the proper commentary on the methods we have pursued. Before these methods were adopted the unbridled imagination roamed through

nature, putting in the place of law the figments of superstitious dread. For thousands of years witchcraft, and magic, and miracles, and special providences, and Mr. Mozley's "distinctive reason of man," had the world to themselves. They made worse than nothing of it—*worse*, I say, because they let and hindered those who might have made something of it. Hence it is that during a single lifetime of this era of "unintelligent impulse" the progress in knowledge is all but infinite, as compared with that of the ages which preceded ours.

The believers in magic and miracles of a couple of centuries ago had all the strength of Mr. Mozley's present logic on their side. They had done for themselves what he rejoices in having so effectually done for us—cleared the ground of the belief in the order of nature, and declared magic, miracles, and witchcraft to be matters for "ordinary evidence" to decide. "The principle of miracles" thus "befriended" had free scope, and we know the result. Lacking that rock-barrier of natural knowledge which we now possess, keen jurists and cultivated men were hurried on to deeds the bare recital of which makes the blood run cold. Skilled in all the rules of human evidence, and versed in all the arts of cross-examination, these men, nevertheless, went systematically astray, and committed the deadliest wrongs against humanity. And why? Because they could not put Nature into the witness-box, and question her—of her voiceless "testimony" they knew nothing. In all cases between man and man their judgment was to be relied on; but in all cases between man and nature they were blind leaders of the blind.[1]

Mr. Mozley concedes that it would be no great result if miracles were only accepted by the ignorant and superstitious, "because it is easy to satisfy those who do not inquire." But he does consider it "a great result" that they have been accepted by the educated. In what sense educated? Like those statesmen, jurists, and Church dignitaries whose education was unable to save them from the frightful errors glanced at above? Not even in this sense; for the great mass of Mr. Mozley's educated people had no legal training, and must have been absolutely defenceless against delusions which could set even that training at naught. Like nine-tenths of our clergy at the present day, they were versed in the literature of Greece, Rome, and Judea; but as regards a knowledge of nature, which is here the one thing needful, they were "noble savages," and nothing more. In the case of miracles, then, it behoves us to understand the weight of the negative before we assign a value to the positive; to comprehend the depositions of nature before we attempt to measure, with them, the evidence of men. We have only to open our eyes to see what honest and even intellectual men and women are capable of, as to judging evidence, in this nineteenth century of the Christian era, and in latitude fifty-two degrees north. The experience thus gained ought, I imagine, to influence our opinion regarding the testimony of people inhabiting a sunnier clime, with a richer imagination and without a particle of that restraint which the discoveries of physical science have imposed upon mankind.

Having thus submitted Mr. Mozley's views to the examination which they challenged at the hands of a student of nature, I am unwilling to quit his book without expressing my admiration of his genius

[1] "In 1664 two women were hung in Suffolk, under a sentence of Sir Matthew Hale, who took the opportunity of declaring that the reality of witchcraft was 'unquestionable; 'for first, the Scriptures had affirmed so much; and secondly, the wisdom of all nations had provided laws against such persons, which is an argument of their confidence of such a crime.' Sir Thomas Browne, who was a great physician as well as a great writer, was called as a witness, and swore 'that he was clearly of opinion that the persons were bewitched.'"—Lecky's *History of Rationalism*, vol. i., p. 120.

and my respect for his character. Though barely known to him personally, his recent death affected me as that of a friend. With regard to the style of his book, I heartily subscribe to the description with which the *Times* winds up its able and appreciative review: "It is marked throughout with the most serious and earnest conviction, but is without a single word from first to last of asperity or insinuation against opponents; and this not from any deficiency of feeling as to the importance of the issue, but from a deliberate and resolutely maintained self-control, and from an over-ruling, ever-present sense of the duty, on themes like these, of a more than judicial calmness."

ADDITIONAL REMARKS ON MIRACLES

Among the scraps of manuscripts, written at the time when Mr. Mozley's work occupied my attention, I find the following reflections:—

With regard to the influence of modern science, which Mr. Mozley rates so low, one obvious effect of it is to enhance the magnitude of many of the recorded miracles, and to increase proportionably the difficulties of belief. The ancients knew but little of the vastness of the universe. The Rev. Mr. Kirkman, for example, has shown what inadequate notions the Jews entertained regarding the "firmament of heaven"; and Sir George Airy refers to the case of a Greek philosopher who was persecuted for hazarding the assertion, then deemed monstrous, that the sun might be as large as the whole country of Greece. The concerns of a universe, regarded from this point of view, were much more commensurate with man and his concerns than those of the universe which science now reveals to us; and hence that to suit man's purposes, or that in compliance with his prayers, changes should occur in the order of the universe, was more easy of belief in the ancient world than it can be now. In the very magnitude which it assigns to natural phenomena, science has augmented the distance between them and man, and increased the popular belief in their orderly progression.

As a natural consequence, the demand for evidence is more exacting than it used to be whenever it is affirmed that the order of nature has been disturbed. Let us take as an illustration the miracle by which the victory of Joshua over the Amorites was rendered complete. In this case the sun is reported to have stood still for "about a whole day" upon Gibeon, and the moon in the valley of Ajalon. An Englishman of average education at the present day would naturally demand a greater amount of evidence to prove that this occurrence took place than would have satisfied an Israelite in the age succeeding that of Joshua. For to the one the miracle probably consisted in the stoppage of a fiery ball less than a yard in diameter, while to the other it would be the stoppage of an orb fourteen hundred thousand times the earth in size. And even accepting the interpretation that Joshua dealt with what was apparent merely, but that what really occurred was the suspension of the earth's rotation, I think the right to exercise a greater reserve in accepting the miracle, and to demand stronger evidence in support of it than that which would have satisfied an ancient Israelite, will still be conceded to a man of science.

There is a scientific as well as an historic imagination; and when, by the exercise of the former, the stoppage of the earth's rotation is clearly realised, the event assumes proportions so vast, in comparison with the result to be obtained by it, that belief reels under the reflection. The energy here involved is equal to that of six trillions of horses working for the whole of the time employed by Joshua in the destruction of his foes. The amount of power thus expended would be sufficient to supply every individual of an army a thousand times the strength of that of Joshua, with a thousand

times the fighting power of each of Joshua's soldiers, not for the few hours necessary to the extinction of a handful of Amorites, but for millions of years. All this wonder is silently passed over by the sacred historian, manifestly because he knew nothing about it. Whether, therefore, we consider the miracle as purely evidential, or as a practical means of vengeance, the same lavish squandering of energy stares us in the face. If evidential, the energy was wasted because the Israelites knew nothing of its amount; if simply destructive, then the ratio of the quantity lost to the quantity employed may be inferred from the foregoing figures.

To other miracles similar remarks apply. Transferring our thoughts from this little sand-grain of an earth to the immeasurable heavens, where countless worlds with freights of life probably revolve unseen, the very suns which warm them being barely visible across abysmal space, reflecting that beyond these sparks of solar fire suns innumerable may burn, whose light can never stir the optic nerve at all, and bringing these reflections face to face with the idea of the Builder and Sustainer of it all showing Himself in a burning bush, exhibiting His hinder parts, or behaving in other familiar ways ascribed to Him in the Jewish Scriptures, the incongruity must appear. Did this credulous prattle of the ancients about miracles stand alone; were it not associated with words of imperishable wisdom, and with examples of moral grandeur unmatched elsewhere in the history of the human race, both the miracles and their "evidences" would have long since ceased to be the transmitted inheritance of intelligent men. Influenced by the thoughts which this universe inspires, well may we exclaim in David's spirit, if not in David's words: "When I consider the heavens, the work of thy fingers, the moon, and the stars, which thou hast ordained, what is man that thou shouldst be mindful of him, or the son of man that thou shouldst so regard him?"

If you ask me who is to limit the outgoings of Almighty power, my answer is, Not I. If you should urge that, if the Builder and Maker of this universe chose to stop the rotation of the earth, or to take the form of a burning bush, there is nothing to prevent Him from doing so, I am not prepared to contradict you. I neither agree with you nor differ from you, for it is a subject of which I know nothing. But I observe that in such questions regarding Almighty power your inquiries relate, not to that power as it is actually displayed in the universe, but to the power of your own imagination. Your question is, not Has the Omnipotent done so and so? or Is it in the least degree likely that the Omnipotent should do so and so? but, Is my imagination competent to picture a Being able and willing to do so and so? I am not prepared to deny your competence. To the human mind belongs the faculty of enlarging and diminishing, of distorting and combining, indefinitely the objects revealed by the senses. It can imagine a mouse as large as an elephant, an elephant as large as a mountain, and a mountain as high as the stars. It can separate congruities and unite incongruities. We see a fish and we see a woman; we can drop one half of each, and unite in idea the other two halves to a mermaid. We see a horse and we see a man; we are able to drop one half of each, and unite the other two halves to a centaur. Thus also the pictorial representations of the Deity, the bodies and wings of cherubs and seraphs, the hoofs, horns, and tail of the Evil One, the joys of the blessed, and the torments of the damned, have been elaborated from materials furnished to the imagination by the senses. It behoves you and me to take care that our notions of the Power which rules the universe are not mere fanciful or ignorant enlargements of human power. The capabilities of what you call your reason are not denied. By the exercise of the faculty here adverted to, you can picture to yourself a Being able and willing to do any and

every conceivable thing. You are right in saying that in opposition to this Power science is of no avail—that it is "a weapon of air." The man of science, however, while accepting the figure, would probably reverse its application, thinking it is not science which is here the thing of air, but that unsubstantial pageant of the imagination to which the solidity of science is opposed.

ON PRAYER AS A FORM OF PHYSICAL ENERGY

[1872]

THE Editor of the *Contemporary Review* is liberal enough to grant me space for some remarks upon a subject which, though my relation to it was simply that of a vehicle of transmission, has brought down upon me a considerable amount of animadversion.

It may be interesting to some of my readers if I glance at a few cases illustrative of the history of the human mind in relation to this and kindred questions. In the fourth century the belief in Antipodes was deemed unscriptural and heretical. The pious Lactantius was as angry with the people who held this notion as my censors are now with me, and quite as unsparing in his denunciations of their "Monstrosities." Lactantius was irritated because, in his mind, by education and habit, cosmogony and religion were indissolubly associated, and, therefore, simultaneously disturbed. In the early part of the seventeenth century the notion that the earth was fixed, and that the sun and stars revolved round it daily, was interwoven with religious feeling, the separation then attempted by Galileo rousing the animosity and kindling the persecution of the Church. Men still living can remember the indignation excited by the first revelations of geology regarding the age of the earth, the association between chronology and religion being for the time indissoluble. In our day, however, the best informed theologians are prepared to admit that our views of the Universe and its Author are not impaired, but improved, by the abandonment of the Mosaic account of the Creation. Look, finally, at the excitement caused by the publication of the *Origin of Species*, and compare it with the calm attendant on the appearance of the far more outspoken and, from the old point of view, more impious *Descent of Man*.

Thus religion survives after the removal of what had been long considered essential to it. In our day the Antipodes are accepted; the fixity of the earth is given up; the period of Creation and the reputed age of the world are alike dissipated; Evolution is looked upon without terror; and other changes have occurred in the same direction too numerous to be dwelt upon here. In fact, from the earliest times to the present, religion has been undergoing a process of purification, freeing itself slowly and painfully from the physical errors which the active but uninformed intellect mingled with the aspirations of the soul. Some of us think that a final act of purification is needed, while others oppose this notion with the confidence and the warmth of ancient times. The bone of contention at present is *the physical value of prayer*. It is not my wish to excite surprise, much less to draw forth protest, by the employment of this phrase. I would simply ask any intelligent person to look the problem honestly in the face, and then to say whether, in the estimation of the great body of those who sincerely resort to it, prayer does not, at all events upon special

occasions, invoke a Power which checks and augments the descent of rain, which changes the force and direction of winds, which affects the growth of corn and the health of men and cattle—a Power, in short, which, when appealed to under pressing circumstances, produces the precise effects caused by physical energy in the ordinary course of things. To any person who deals sincerely with the subject, and refuses to blur his moral vision by intellectual subtleties, this, I think, will appear a true statement of the case.

It is under this aspect alone that the scientific student, so far as I represent him, has any wish to meddle with prayer. Forced upon his attention as a form of physical energy, or as the equivalent of such energy, he claims the right of subjecting it to those methods of examination from which all our present knowledge of the physical universe is derived. And if his researches lead him to a conclusion adverse to its claims—if his inquiries rivet him still closer to the philosophy implied in the words, "He maketh His sun to shine on the evil and on the good, and sendeth rain upon the just and upon the unjust"—he contends only for the displacement of prayer, not for its extinction. He simply says, physical nature is not its legitimate domain.

This conclusion, moreover, must be based on pure physical evidence, and not on any inherent unreasonableness in the act of prayer. The theory that the system of nature is under the control of a Being who changes phenomena in compliance with the prayers of men is, in my opinion, a perfectly legitimate one. It may, of course, be rendered futile by being associated with conceptions which contradict it; but such conceptions form no necessary part of the theory. It is a matter of experience that an earthly father, who is at the same time both wise and tender, listens to the requests of his children, and, if they do not ask amiss, takes pleasure in granting their requests. We know also that this compliance extends to the alteration, within certain limits, of the current of events on earth. With this suggestion offered by experience, it is no departure from scientific method to place behind natural phenomena a Universal Father, who, in answer to the prayers of his children, alters the currents of those phenomena. Thus far theology and science go hand in hand. The conception of an æther, for example, trembling with the waves of light, is suggested by the ordinary phenomena of wave-motion in water and in air; and in like manner the conception of personal volition in nature is suggested by the ordinary action of man upon earth. I, therefore, urge no *impossibilities*, though I am constantly charged with doing so. I do not even urge inconsistency, but, on the contrary, frankly admit that the theologian has as good a right to place his conception at the root of phenomena as I have to place mine.

But without *verification* a theoretic conception is a mere figment of the intellect, and I am sorry to find us parting company at this point. The region of theory, both in science and theology, lies behind the world of the senses, but the verification of theory occurs in the sensible world. To check the theory, we have simply to compare the deductions from it with the facts of observation. If the deductions be in accordance with the facts, we accept the theory; if in opposition, the theory is given up. A single experiment is frequently devised by which the theory must stand or fall. Of this character was the determination of the velocity of light in liquids as a crucial test of the Emission Theory. According to it, light travelled faster in water than in air; according to the Undulatory Theory, it travelled faster in air than in water. An experiment suggested by Arago, and executed by Fizeau and Foucault, was conclusive against Newton's theory.

But while science cheerfully submits to this ordeal, it seems impossible to devise a mode of verification of their theories which does not rouse resentment in

theological minds. Is it that, while the pleasure of the scientific man culminates in the demonstrated harmony between theory and fact, the highest pleasure of the religious man has been already tasted in the very act of praying prior to verification, any further effort in this direction being a mere disturbance of his peace? Or is it that we have before us a residue of that mysticism of the Middle Ages, so admirably described by Whewell—that "practice of referring things and events, not to clear and distinct notions, not to general rules capable of direct verification, but to notions vague, distant, and vast, which we cannot bring into contact with facts, as when we connect natural events with moral and historic causes"? "Thus," he continues, "the character of mysticism is that it refers particulars not to generalisations homogeneous and immediate, but to such as are heterogeneous and remote; to which we must add, that the process of this reference is not a calm act of the intellect, but is accompanied with a glow of enthusiastic feeling."

Every feature here depicted, and some more questionable ones, have shown themselves of late; most conspicuously, I regret to say, in the "leaders" of a weekly journal of considerable influence, and one, on many grounds, entitled to the respect of thoughtful men. In the correspondence, however, published by the same journal, are to be found two or three letters well calculated to correct the temporary flightiness of the journal itself.

It is not my habit of mind to think otherwise than solemnly of the feeling which prompts prayer. It is a power which I should like to see guided, not extinguished — devoted to practicable objects instead of wasted upon air. In some form or other, not yet evident, it may, as alleged, be necessary to man's highest culture. Certain it is that, while I rank many persons who resort to prayer low in the scale of being—natural foolishness, bigotry, and intolerance being in their case intensified by the notion that they have access to the ear of God—I regard others who employ it as forming part of the very cream of the earth. The faith that adds to the folly and ferocity of the one is turned to enduring sweetness, holiness, abounding charity, and self-sacrifice by the other. Religion, in fact, varies with the nature upon which it falls. Often unreasonable, if not contemptible, prayer, in its purer forms, hints at disciplines which few of us can neglect without moral loss. But no good can come of giving it a delusive value, by claiming for it a power in physical nature. It may strengthen the heart to meet life's losses, and thus indirectly promote physical well-being, as the digging of Æsop's orchard brought a treasure of fertility greater than the golden treasure sought. Such indirect issues we all admit; but it would be simply dishonest to affirm that it is such issues that are always in view. Here, for the present, I must end. I ask no space to reply to those railers who make such free use of the terms "insolence," "outrage," "profanity," and "blasphemy." They obviously lack the sobriety of mind necessary to give accuracy to their statements, or to render their charges worthy of serious refutation.

SCIENCE AND THE "SPIRITS"

[1864]

THEIR refusal to investigate "spiritual phenomena" is often urged as a reproach against scientific men. I here propose to give a sketch of an attempt to apply to the "phenomena" those methods of inquiry which are found available in dealing with natural truth.

Some years ago, when the spirits were particularly active in this country, Faraday was invited, or rather entreated, by one of his friends to meet and question them. He had, however, already made their acquaintance, and did not wish to renew it. I had not been so privileged, and he therefore kindly arranged a transfer of the invitation to me. The spirits themselves named the time of meeting, and I was conducted to the place at the day and hour appointed.

Absolute unbelief in the facts was by no means my condition of mind. On the contrary, I thought it probable that some physical principle, not evident to the spiritualists themselves, might underlie their manifestations. Extraordinary effects are produced by the accumulation of small impulses. Galileo set a heavy pendulum in motion by the well-timed puffs of his breath. Ellicot set one clock going by the ticks of another, even when the two clocks were separated by a wall. Preconceived notions can, moreover, vitiate, to an extraordinary degree, the testimony of even veracious persons. Hence my desire to witness those extraordinary phenomena, the existence of which seemed placed beyond a doubt by the known veracity of those who had witnessed and described them. The meeting took place at a private residence in the neighbourhood of London. My host, his intelligent wife, and a gentleman who may be called X. were in the house when I arrived. I was informed that the "medium" had not yet made her appearance; that she was sensitive, and might resent suspicion. It was therefore requested that the tables and chairs should be examined before her arrival, in order to be assured that there was no trickery in the furniture. This was done; and I then first learned that my hospitable host had arranged that the *séance* should be a dinner-party. This was to me an unusual form of investigation; but I accepted it, as one of the accidents of the occasion.

The "medium" arrived—a delicate-looking young lady, who appeared to have suffered much from ill-health. I took her to dinner and sat close beside her. Facts were absent for a considerable time, a series of very wonderful narratives supplying their place. The duty of belief on the testimony of witnesses was frequently insisted on. X. appeared to be a chosen spiritual agent, and told us many surprising things. He affirmed that, when he took a pen in his hand, an influence ran from his shoulder downwards, and impelled him to write oracular sentences. I listened for a time, offering no observation. "And now," continued X., "this power has so risen as to reveal to me the thoughts of others. Only this morning I told a friend what he was thinking of, and what he intended to do during the day." Here, I thought, is something that can be at once tested. I said immediately to X.: "If you wish to win to your cause an apostle, who will proclaim your principles to the world from the housetop, tell me what I am now thinking of." X. reddened, and did *not* tell me my thought.

Some time previously I had visited Baron Reichenbach, in Vienna, and I now asked the young lady who sat beside me whether she could see any of the

curious things which he describes—the light emitted by crystals, for example? Here is the conversation which followed, as extracted from my notes, written on the day following the *séance*:—

Medium.—"Oh, yes; but I see light around all bodies."

I.—"Even in perfect darkness?"

Medium.—"Yes; I see luminous atmospheres round all people. The atmosphere which surrounds Mr. R. C. would fill this room with light."

I.—"You are aware of the effects ascribed by Baron Reichenbach to magnets?"

Medium.—"Yes; but a magnet makes me terribly ill."

I.—"Am I to understand that, if this room were perfectly dark, you could tell whether it contained a magnet, without being informed of the fact?"

Medium.—"I should know of its presence on entering the room."

I.—"How?"

Medium.—"I should be rendered instantly ill."

I.—"How do you feel to-day?"

Medium.—"Particularly well; I have not been so well for months."

I.—"Then, may I ask you whether there is, at the present moment, a magnet in my possession?"

The young lady looked at me, blushed, and stammered:

"No; I am not *en rapport* with you."

I sat at her right hand, and a left-hand pocket, within six inches of her person, contained a magnet.

Our host here deprecated discussion, as it "exhausted the medium." The wonderful narratives were resumed; but I had narratives of my own quite as wonderful. These spirits, indeed, seemed clumsy creations, compared with those with which my own work had made me familiar. I therefore began to match the wonders related to me by other wonders. A lady present discoursed on spiritual atmospheres, which she could see as beautiful colours when she closed her eyes. I professed myself able to see similar colours, and, more than that, to be able to see the interior of my own eyes. The medium affirmed that she could see actual waves of light coming from the sun. I retorted that men of science could tell the exact number of waves emitted in a second, and also their exact length. The medium spoke of the performances of the spirits on musical instruments. I said that such performance was gross, in comparison with a kind of music which had been discovered some time previously by a scientific man. Standing at a distance of twenty feet from a jet of gas, he could command the flame to emit a melodious note; it would obey, and continue its song for hours. So loud was the music emitted by the gas-flame that it might be heard by an assembly of a thousand people. These were acknowledged to be as great marvels as any of those of spiritdom. The spirits were then consulted, and I was pronounced to be a first-class medium.

During this conversation a low knocking was heard from time to time under the table. These, I was told, were the spirits' knocks. I was informed that one knock, in answer to a question, meant "No"; that two knocks meant "Not yet"; and that three knocks meant "Yes." In answer to a question whether I was a medium, the response was three brisk and vigorous knocks. I noticed that the knocks issued from a particular locality, and therefore requested the spirits to be good enough to answer from another corner of the table. They did not comply; but I was assured that they would do it, and much more, by-and-by. The knocks continuing, I turned a wine-glass upside down, and placed my ear upon it, as upon a stethoscope. The spirits seemed disconcerted by the act; they lost their playfulness, and did not recover it for a considerable time.

Somewhat weary of the proceedings, I once threw myself back against my chair and gazed listlessly out of the window. While thus engaged, the table was rudely pushed. Attention was drawn to the

wine, still oscillating in the glasses, and I was asked whether that was not convincing. I readily granted the fact of motion, and began to feel the delicacy of my position. There were several pairs of arms upon the table, and several pairs of legs under it; but how was I, without offence, to express the conviction which I really entertained? To ward off the difficulty, I again turned a wine-glass upside down and rested my ear upon it. The rim of the glass was not level, and my hair, on touching it, caused it to vibrate, and produce a peculiar buzzing sound. A perfectly candid and warm-hearted old gentleman at the opposite side of the table, whom I may call A., drew attention to the sound, and expressed his entire belief that it was spiritual. I, however, informed him that it was the moving hair acting on the glass. The explanation was not well received; and X., in a tone of severe pleasantry, demanded whether it was the hair that had moved the table. The promptness of my negative probably satisfied him that my notion was a very different one.

The superhuman power of the spirits was next dwelt upon. The strength of man, it was stated, was unavailing in opposition to theirs. No human power could prevent the table from moving when they pulled it. During the evening this pulling of the table occurred, or rather was attempted, three times. Twice the table moved when my attention was withdrawn from it; on a third occasion, I tried whether the act could be provoked by an assumed air of inattention. Grasping the table firmly between my knees, I threw myself back in the chair, and waited, with eyes fixed on vacancy, for the pull. It came. For some seconds it was pull spirit, hold muscle; the muscle, however, prevailed, and the table remained at rest. Up to the present moment, this interesting fact is known only to the particular spirit in question and myself.

A species of mental scene-painting, with which my own pursuits had long rendered me familiar, was employed to figure the changes and distribution of spiritual power. The spirits, it was alleged, were provided with atmospheres, which combined with and interpenetrated each other, and considerable ingenuity was shown in demonstrating the necessity of time in effecting the adjustment of the atmospheres. A re-arrangement of our positions was proposed and carried out; and soon afterwards my attention was drawn to a scarcely sensible vibration on the part of the table. Several persons were leaning on the table at the time, and I asked permission to touch the medium's hand. "Oh! I know I tremble," was her reply. Throwing one leg across the other, I accidentally nipped a muscle, and produced thereby an involuntary vibration of the free leg. This vibration, I knew, must be communicated to the floor, and thence to the chairs of all present. I therefore intentionally promoted it. My attention was promptly drawn to the motion; and a gentleman beside me, whose value as a witness I was particularly desirous to test, expressed his belief that it was out of the compass of human power to produce so strange a tremor. "I believe," he added, earnestly, "that it is entirely the spirits' work." "So do I," added, with heat, the candid and warm-hearted old gentleman A. "Why, sir," he continued, "I feel them at this moment shaking my chair." I stopped the motion of the leg. "Now, sir," A. exclaimed, "they are gone." I began again, and A. once more affirmed their presence. I could, however, notice that there were doubters present, who did not quite know what to think of the manifestations. I saw their perplexity; and, as there was sufficient reason to believe that the disclosure of the secret would simply provoke anger, I kept it to myself.

Again a period of conversation intervened, during which the spirits became animated. The evening was confessedly a dull one, but matters appeared to brighten towards its close. The spirits were requested to spell the name by

which I was known in the heavenly world. Our host commenced repeating the alphabet, and when he reached the letter "P" a knock was heard. He began again, and the spirits knocked at the letter "O." I was puzzled, but waited for the end. The next letter knocked down was "E." I laughed, and remarked that the spirits were going to make a poet of me. Admonished for my levity, I was informed that the frame of mind proper for the occasion ought to have been superinduced by a perusal of the Bible immediately before the *séance.* The spelling, however, went on, and sure enough I came out a poet. But matters did not end here. Our host continued his repetition of the alphabet, and the next letter of the name proved to be "O." Here was manifestly an unfinished word; and the spirits were apparently in their most communicative mood. The knocks came from under the table, but no person present evinced the slightest desire to look under it. I asked whether I might go underneath; the permission was granted; so I crept under the table. Some tittered; but the candid old A. exclaimed: "He has a right to look into the very dregs of it, to convince himself." Having pretty well assured myself that no sound could be produced under the table without its origin being revealed, I requested our host to continue his questions. He did so, but in vain. He adopted a tone of tender entreaty; but the "dear spirits" had become dumb dogs, and refused to be entreated. I continued under that table for at least a quarter of an hour, after which, with a feeling of despair as regards the prospects of humanity never before experienced, I regained my chair. Once there, the spirits resumed their loquacity, and dubbed me "Poet of Science."

This, then, is the result of an attempt made by a scientific man to look into these spiritual phenomena. It is not encouraging; and for this reason. The present promoters of spiritual phenomena divide themselves into two classes, one of which needs no demonstration, while the other is beyond the reach of proof. The victims like to believe, and they do not like to be undeceived. Science is perfectly powerless in the presence of this frame of mind. It is, moreover, a state perfectly compatible with extreme intellectual subtlety and a capacity for devising hypotheses which only require the hardihood engendered by strong conviction, or by callous mendacity, to render them impregnable. The logical feebleness of science is not sufficiently borne in mind. It keeps down the weed of superstition, not by logic, but by slowly rendering the mental soil unfit for its cultivation. When science appeals to uniform experience, the spiritualist will retort: "How do you know that a uniform experience will continue uniform? You tell me that the sun has risen for six thousand years: that is no proof that it will rise to-morrow; within the next twelve hours it may be puffed out by the Almighty." Taking this ground, a man may maintain the story of "Jack and the Beanstalk" in the face of all the science in the world. You urge, in vain, that science has given us all the knowledge of the universe which we now possess, while spiritualism has added nothing to that knowledge. The drugged soul is beyond the reach of reason. It is in vain that impostors are exposed, and the special demon cast out. He has but slightly to change his shape, return to his house, and find it "empty, swept, and garnished."

Since the time when the foregoing remarks were written I have been more than once among the spirits, at their own invitation. They do not improve on acquaintance. Surely no baser delusion ever obtained dominance over the weak mind of man.

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